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TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK 413
A Bridge that Ought to be Better (Illustrated)..... 414
Electric Distribution from Central Stations by Direct and by Alternating Currents 414
Some Novelties in Swing Bridge Construction on the Trent Valley Canal (Illustrated)................ 417
Experiments on Cast-Iron Cylinders (Illustrated).. 417
An Electrical Device for Operating Hydraulic Valves at a Distance (Illustrated)..................... 419
The Twin Lakes Reservoir, Colorado............. 419
Tests of Full-Sized Cast-Iron Columns (Illustrated). 424
Engineering Work in the Hawaiian Islands (Illustrated) 425
The Adoption of a Standard System of Test Bars for Cast Iron 425
The Boston Department of Municipal Statistics....... 426
The Zermatt-Gornergrat Electric Rack Railway.... 427
Book Reviews 427
Annual Convention of the American Railway Master Mechanics' Association 428
EDITORIAL NOTES 420
The Strength of Cast-Iron Columns—A New Basic Steel Plant at Ensley, Ala.—Tests of Cast-Iron Cylinders—Is the Coating of Cast-Iron Pipe Needed to Make it Water Tight?
EDITORIAL:
The Work of the Railway Mechanical Conventions of 1898.... 421
LETTERS TO THE EDITOR 422
Vandyke Solar Paper for Blue Print Negatives—Tests of Cast-Iron Columns—The Effect of Temperature on the Flow of Water Through Soils—Across Wyoming by the Union Pacific.

THE NEW STEEL PLANT, to be erected at Ensley, Ala., six miles from Birmingham, which has been projected for a long time, is now assured of erection. A corporation called the Alabama Steel & Shipbuilding Co. has been organized, with Moore & Schley, bankers, of New York city, as financial agents. It has been decided to issue $1,100,000 of 6% bonds, $400,000 of 6% preferred stock and $50,000 common stock. The bonds are guaranteed by the Tennessee Coal, Iron & Railroad Co. and have already been subscribed in full, the Louisville & Nashville R. R. Co. and the Southern Ry. taking $200,000 each, Moore & Schley $143,000, and sundry parties in Birmingham $182,000. The contract for the erection of the works has been given to the Wellman-Seaver Engineering Co., of Cleveland, O. Mr. S. T. Wellman, of this firm, was for many years manager of the Otis Steel Co., of Cleveland, and more recently was president of the Wellman Steel Co. of Chester, Pa. The plant will be a basic open-hearth steel works of 1,000 tons daily capacity, containing ten 50-ton Wellman rolling furnaces, with a blooming mill, a continuous billet mill for rolling down to 1½ ins. square, a rail mill, and the necessary heating furnaces and other equipment. It is intended to take melted pig metal from the Ensley blast furnaces of the Tennessee Coal, Iron & Railroad Co., and pour it into a mixer, of 300 tons capacity, from which it will be taken to the open-hearth furnaces. The machinery of the plant will all be of the most modern type, and it will have one new feature not yet possessed by any other steel works in this country, viz., a plant of Semet-Solvay coke ovens with provision for utilizing their waste gas as a supplement to the gas made by the ordinary producers. The products of the works will be chiefly slabs and blooms, billets, rods, tin-plate bars and rails. It is expected that the works will be in operation within a year.

THE NEW VICKERS 6-IN. WIRE-WOUND RAPID-fire gun, officially tested some time ago at Portsmouth, England, is 45 calibers long and weighs 7 tons 8 cwt. The breech mechanism is lighter and stronger than in older types, and a single motion of a horizontal lever opens and closes it. In the trial this gun developed a muzzle velocity of 2,780 ft. sec. and a pressure of 15.9 tons per sq. in. on the breech. The striking energy of the projectile was 5,374 ft.-tons, as compared with 3,556 ft.-tons in the ordinary 6-in. gun. Aiming at a target 3,000 yds. away, the rate of firing was one round in 10 seconds; and unaimed shots were fired at the rate of one in 9½ seconds. In all, 110 rounds were fired without any damage to the gun or its mount. In a second trial, after 200 rounds had been fired, the gun showed no decrease of accuracy; in the test for rapidity of fire 36 rounds were fired in 4 m. 47 s., and the maximum was one round in 6½ seconds, and one set of eight rounds in 7 seconds each.

THE TORPEDO BOAT "ROWAN," in a preliminary trial run at Tacoma, made 25 knots under 175 lbs. of steam. The boilers will withstand 250 lbs., and she will probably exceed her contract speed of 26 knots over the 80-mile official course now being laid out, from Tacoma up the Sound.

A CUBAN ROAD-MAKING MANUAL has been issued for the use of our troops by Gen. Roy Stone, of the Road Bureau in the Agricultural Department, and now on the staff of Gen. Miles. The instructions provide for the use of such material as is available in Cuba. Fascines of guava branches, laid lengthwise and overlapping, with earth between each layer, are recommended for the transport of troops and field artillery. For improving sand roads sugar cane is suggested, laid in alternate layers with sand. Full instructions are given for clearing the roads of tropical growth and for the passage of swampy ground.

THE UNITED STATES NAVY, according to the new Naval Register, now includes 1,755 officers; 693 volunteer officers have also been appointed for service during the war and 182 officers of the retired list are placed on active duty. The regular navy includes 11 first-class ships of war, 18 second-class, 43 third-class and 6 fourth-class; 35 torpedo-boats are building and authorized. The auxiliary navy contains 36 cruisers and yachts, 32 steamers and colliers, 25 tugs, 15 revenue cutters, 4 lighthouse tenders and 2 Fish Commission vessels. The regular navy has 78 vessels in commission, and the auxiliary navy includes 114 vessels of all types.

WATERPROOF CLOTHING FOR SOLDIERS has been made a subject of study by Dr. A. Berthier, says the "Revue D'Hygiene," of May 20, 1898. What is wanted is a material that will repel water and yet admit air for ventilation. Dr. Berthier remarks that the clothes of the Arabs seems to possess these contradictory qualities, and he ascribes this to their use of wool which still contains the animal grease. Experiments were made with lanoline, a product of the purification of this animal grease, deprived of soap and acid fat and made neutral. The results were very favorable, and the impermeable effect was secured by a mixture of 10 to 20 grammes of lanoline to 1,000 grammes of spirits of petroleum as a dissolvent. This spread itself rapidly in the tissue and evaporated quickly. The material was made impermeable, either by dipping it in the mixture for a few moments and then wringing out, or by applying it with a sponge to the surface. The last was the most economical; but the first process was best in results. A solution of alum and acetate of lead was also tried with some success. Neutral Animal Fat No. 1, so called, was the best; this material is yellow-brown in color, of a firm consistency, and dissolves more completely in the petroleum spirits than the lanoline. Material thus treated is healthy, the tissue is not clogged, the weight is not increased, and it dries rapidly in the open air. It does not affect the color or the firmness of the material. But washing with soap may reduce these qualities; turpentine destroys it, but it is not affected by benzine or alcohol. The lanoline costs about 64 cts. per pound. The composition of this grease and wax was found to be excellent in keeping the feet in good condition, as it lubricated the skin and made it better resist the friction of the shoe-leather on the march. It was also beneficial when applied directly to the leather.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred June 26 on the Kansas City, Memphis & Birmingham R. R., at Tupelo, Miss. One section of a train carrying a portion of a regiment of cavalry from Cheyenne, Wyo., to Jacksonville, Fla., had stopped for water when the second section rounded a curve at full speed and ran into the rear of the first section. Several of the cars were telescoped and completely wrecked, killing 4 men and injuring 16, among the latter the colonel of the regiment. The engineer of the second section is blamed in the press dispatches, but nothing is said as to the flagman of the first section, who ought to have been out protecting his train while it was at a standstill. Incidentally, it may be remarked that no road not operated on the block system has any business to run trains in sections at all, unless they are kept spaced at least a station apart by the train dispatchers.

A CHINESE TORPEDO BOAT DESTROYER was driven ashore at Port Arthur, China, during a recent typhoon and 130 men were drowned.

ALL BIDS FOR A NEW WATER SUPPLY FOR JERSEY City have again been rejected. This action was taken by the street and water board on June 23, by a vote of 3 to 2. The bids rejected were received last February. It is proposed to readvertise for bids "on such basis as may be determined" by the board in the future. We have lost all track of the number of times water supply bids have been received by Jersey City in the last few years, but believe it is somewhere between 6 and 10.

THE CONSUMPTION OF WATER in small European towns was recently discussed by A. Oelwein, in the "Journal of the Austrian Society of Engineers and Architects." He takes as an example the town of Iglau, with 1,304 houses and 24,100 inhabitants. For the average of five years he obtains the following consumption: Per month, 966,620 cu. ft.; per day, 31,876 cu. ft.; per day per head, 1.33 cu. ft., or not quite 10 gallons.

AN ABNORMAL RAINFALL of 31.72 ins. in 24 hours is reported by the "Ceylon Observer" as falling at Nedunkeni, in North Ceylon. The village is 122 ft. above sea-level and a little east of the dividing ridge of North Ceylon. The country is covered by dense forests. The mean annual rainfall at this place for threee years past is about 50 ins.; but the fall in last December was 67.07 ins., and in this is included the 31.72 ins. referred to.

THE CARRIBEAN AND PACIFIC TRANSIT CO. is a Liverpool corporation and branch of the Atlas Steamship Co., which is said to be concluding arrangements with the State of Nicaragua for the purchase of the state steamboats and the exclusive privilege, for 30 years, of navigating the San Juan River and Lake Nicaragua. The franchise would include the right to deepen parts of the channel, and to build a railway along the river. The price asked by Nicaragua for the concession is $6,000,000. The New York "Herald," which gives out this item, says that this proposed railway up the San Juan would be in direct opposition to the proposed Nicaragua ship canal, and limit its location.

THE BROOKLYN ELEVATED RAILWAY LINES have accepted a modified contract for the movement of their cars across the East River Bridge. Experience proved that the contract of Aug. 23, 1897, would involve an annual loss to the city of about $600,000, and Bridge Commissioner Shea insisted upon other terms under the penalty of annulling the contract altogether. The old contract provided that the elevated cars while on the bridge should be under the exclusive management of the Bridge trustees, who were to furnish employees and power, and for these privileges the elevated railway companies paid 12½ cts. per car per trip. Under the new contracts with the Brooklyn Elevated and Kings County Elevated companies these companies will assume all the expense of operating their cars across the bridge, under the direction of the Bridge Commissioner. They will keep all plant in repair and provide the power. They also pay a toll of 10 cts. per round trip for each car. They further undertake the operation of the bridge railway proper on which a fare of 2½ cts. is charged. They agree to stand any loss incurred in the operation of this road and if it shall prove profitable they shall pay a percentage of the profits to the city as follows: 5% between $10,000 and $20,000; 7½% up to $40,000; 10% up to $60,000; 12½% up to $80,000; 15% to $100,000; 20% to $150,000 and $25% on all profits exceeding $150,000. The elevated companies must bear whatever loss may occur in operation. The Brooklyn Elevated will also pay $20,306.26 annually for the use of tracks and switches, and is to guarantee that the car rental shall not be less than $250 per day, up to the time the Kings County road begins operations, and $166.67 thereafter.

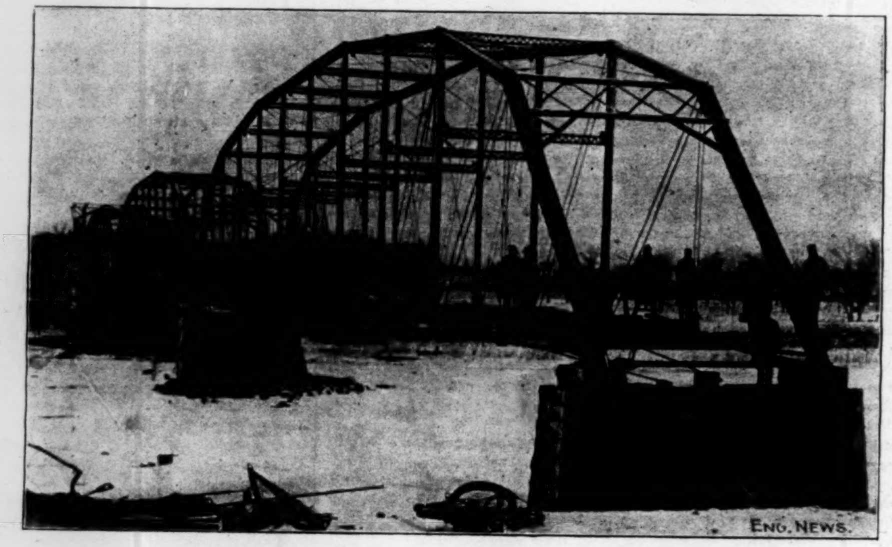
AN ICE-BREAKING STEAMER is being built in England, for use between Cronstadt and St. Petersburg in winter, and in the Kara Sea in summer. This vessel will be 305 ft. long, with double bottom, and double skin; with four sets of powerful engines and a coal capacity of 5,000 tons. She is to cost $875,000 and will be more powerful than the Vladivostock ice-breaker, lately built at Copenhagen; the latter had engines of 3,600 HP.

ARCTIC EXPLORATION, for the year, is inaugurated by the sailing of the Wellman expedition from Tromsoe, Norway, on June 26. The auxiliary steamer "Hope," of the Peary expedition, sailed from St. Johns, N. B., on the same day, with a scientific party bound for North Baffin's Bay, and coal and stores for Peary's steamer "Windward," which are to be landed at Littleton Island, off the coast of Greenland. Captain Otto Sverdrup also sailed on June 24 from Norway in the "Fram" for a winter harbor on the north Greenland coast. He proposes to there study the different forms of Arctic life and phenomena and by sledges explore North Greenland. The "Fram" will carry supplies for 16 men for four years, and include in this crew an astronomer, cartographer, meteorologist, zoologist and geologist. The total expense of this expedition is met by Consul Axel Heiberg and Messrs. Arnaud and Ellef Ringnes. By some, this expedition is considered as poaching upon Mr. Peary's domains in Greenland.

NEW ELEMENTS IN THE ATMOSPHERE, discovered by the use of liquefied air, are reported to the Royal Society by Professor Ramsay and Mr. Travers. A large quantity of argon was separated from atmospheric nitrogen, and the latter gas was separated by magnesium. The residue was then liquefied by the cooling effect of liquid air. They found a product with a density of 13 instead of 20 as for argon, with a spectrum differing from that of known gases. This they called neon. By continued distillation they obtained from the liquid argon a solid which only slowly evaporized. The gas into which this solid was converted had practically the same density as argon, but its spectrum was altogether different and peculiar, consisting for the most part of bands, not lines. They called this metargon.

A BRIDGE THAT OUGHT TO BE BETTER.

We illustrate herewith a highway bridge recently erected across the Cedar River, near Iowa City, Ia., which has been made the subject of some criticisms published in the "Iowa State Press" of May 11, which may prove of interest to those of our readers who are interested in raising the standard of highway bridge designing. The bridge was built from plans and specifications prepared by Geo. W. Wynn, of Cedar Rapids. The contractor, a Mr. Sheeley, of Des Moines, built the whole work, substructure, superstructure and approaches, for the sum of $12,000. The four stone piers are each 16 ft. in height and rest on pile and grillage foundations. The spans are each 214 ft. 6 ins. in length, and the approaches, which rest on red cedar piles, are each about 100 ft. in length. The ironwork was built at the works of the Fair-Williams Bridge & Manufacturing Co. of Ottumwa.



BRIDGE OVER THE CEDAR RIVER, JOHNSON COUNTY, IA.

The Board of Supervisors of Johnson County, under whose direction the work was done, appear to have had some doubts as to the sufficiency of the structure for the loads to be imposed upon it, and asked Mr. J. A. L. Waddell, M. Am. Soc. C. E., to report upon it.

The principal criticisms made by Mr. Waddell were as follows:

1. The computer who made the original calculations for stresses evidently was unaware of the fact that a partial load has a greater effect on the web of a truss than has a load over the whole span. On this account the second, third and fourth main diagonals are too small, and ought to be replaced.

2. The bottom chord pins, excepting those at the pedestals, are too small for the bars. This is a fault that cannot be remedied without practically throwing away the whole bridge and putting in a new one.

3. The inclined end posts are overstrained about 30% by the eccentricity of the pin holes in respect to gravity lines.

4. These inclined end posts were evidently not figured for bending by wind pressure, consequently they would be considerably overstrained in a wind storm; but it would involve too much trouble and expense to strengthen them adequately, so the bridge will have to take its chance of being blown down. This chance, however, is very small.

5. The two panels of the bottom chords at each end of span ought to have been strengthened to resist wind pressure, and I advise that stiff members be put in at these places. In truth, the remainder of the bottom chords will not bear figuring for reversion of stress due to wind pressure.

6. The portals are most unscientifically designed, and should be replaced by good end effective bracing. Such bracing will aid materially the too weak inclined end posts in resisting bending from wind pressure.

7. The lower lateral rods are very eccentrically connected, thus nullifying a large portion of the benefit that would be obtained by the great strength of these rods. This is a fault, however, that cannot well be remedied.

8. The connecting plates for the end lower lateral rods are not thick enough, but it would do no good to change them, because of the reason given in the last item.

9. The channels for the four posts nearest mid-span are smaller than good practice allows, and consequently tend to start vibration.

10. The roller plates should be made ⅝-in. thick instead of ⅜-in. This is a fault that is easily corrected.

15. I notice that the webs of the vertical posts are very much thinner than good practice allows. The 5-in. channels have webs only 0.17-in. thick, and the 6-in. channel's webs 0.2-in. thick. My minimum limit of thickness for metal in cheap highway bridges is 5-16-in., or 0.31-in., but some standard specifications permit the use of metal ¼-in. thick. The effect of the use of such thin metal as you have in these posts will be a quick rusting out of the webs.

In further explanation of some of the points raised by Mr. Waddell, we may add that the reason for using larger pins than those adopted in this bridge is not that the pin itself is not strong enough, but that with too small pins the pressure upon the eye becomes so great as to tend to crush the metal, and make the eye weaker than the rest of the bar. Concerning the omission to place the pinholes in the end posts at the center of gravity of the section, few designers realize the importance of this. In the present case the pinholes were less than an inch from their proper position, but the result was to increase the fiber stress in the end post by 30%. It costs no more to bore a pinhole in the correct position than somewhere else.

The function of roller plates is not only to give a smooth track for the rollers, but to distribute evenly the pressure upon the masonry.

Weak and ineffective portal bracing is a common fault in highway bridges. Designers do not seem to appreciate the fact that all the lateral pressure against the upper part of the trusses must be carried down to their feet through the portal bracing, if the bridge stands up.

The common argument when criticisms are made of highway bridge work is that the taxpayers cannot afford anything but the cheapest class of work. They must build bridges of small cost or build none at all, and they can better afford to run some risk in the use of such cheap bridges than to continue to run the risks of fording streams and the dangers of being cut off from access to markets, physicians, etc., in times of flood.

All these facts may be freely admitted, and bridge engineers certainly recognize that proper consideration must be given to them in preparing specifications for country bridges. It does not at all follow, however, that the bridge which costs the least money is the most economical bridge to build. If a town or county can afford to build a bridge at all, it can afford to build one which will be durable, and which will be fairly secure against wreck by wind storms (we do not mean tornadoes).

Referring to the present illustration, it may be assumed, we presume, that the county authorities intended to build a good and durable bridge which should also be of the smallest possible cost. They have certainly secured an astonishingly large amount of work for a small sum of money. The contractor claims, we understand, that he lost $2,500 on the job, and it seems not at all unlikely. But for a very slight additional expense they could have secured a structure, so much stronger, safer, and of longer life, that it seems to us a serious error not to have incurred it. Several of the defects shown by Mr. Waddell could have been avoided with practically no additional expense in construction, merely by a little more intelligence on the part of the designer. Other defects would have been avoided by the use of a little more metal. It is strange how persistently some of those engaged in highway bridge construction cling to the old idea that economy is to be sought by paring down the sections of members. In the days when bridge metal cost two or three times as much per pound as it does to-day, there was some economy to be made by saving metal. At the present time, however, the difference in cost between weak sections and fairly good sections in the ordinary highway bridge is trifling. We can divide the cost of any bridge structure into three parts—material, shopwork and erection. The two last items are practically not affected at all by such moderate differences in the weights of metal as those which we are discussing. If those who design or buy highway bridges would keep these facts clearly in mind, we should see less of such penny-wise economies as have been introduced in this Cedar River bridge. Taking the average highway bridge as erected, it is probably safe to say that an addition of 10% to 25% to the weight of the metal work, put where it would do the most good, and coupled, of course, with intelligent design in the first place, would change the bridge from a dangerous to a safe, stiff and durable structure. When we consider the cost of foundations, approaches, and shopwork, and the cost of selling and erection, it is probable that such an addition to the weight of the superstructure would mean an increase of not more than 2% to 7% in the total cost of the completed bridge.

If this fact could be brought home to the comprehension of every public officer in charge of highway bridge construction, it would be of great benefit in raising the standard of American highway bridges.

ELECTRIC DISTRIBUTION FROM CENTRAL STATIONS BY DIRECT AND BY ALTERNATING CURRENTS.

Two papers on the distribution of direct and alternating electric current from central stations were presented at the recent convention of the National Electric Light Association, in Chicago, and the following are abstracts of both of them:

Distribution by Direct Currents.[*]

The general design of the modern direct-current central station and its equipment has been fairly well established within the past five years, and while it was originally the custom to erect the generating stations as nearly as possible in the electrical center of the city or town, it is now generally conceded that direct-current may be more economically distributed from a condensing station, situated even a mile distant from the electrical center than from a non-condensing station located at the electrical center of the city. It has been further demonstrated that the former practice of building many central generating stations in various centers of distribution in cities is to be supplanted by the use of one or two large condensing stations generating direct-current for distribution throughout the business district, if the station be within one mile of the electrical center of the district, and alternating current for transmission to sub-stations located at the electrical centers of districts more remote from the main generating station. In some cities water for condensing purposes may not be easily obtainable within a distance of one mile, and the location is then merely a question of total cost of land, building and transmission lines to the various distributing stations, proper consideration being given, of course, to the limitations of line voltage and insulation.

In order to show the workings of the first-mentioned type of modern direct-current central station systems, I will explain in a general way the method of distribution employed in the system of the Chicago Edison Co., which fairly represents the latest development.

The system of distribution is a solid network of underground conductors on the three-wire system, extending a distance of six miles north and south, and a distance of 1½ miles east and west. The system is continuous, and is supplied at present from four central stations, all connected in parallel and each feeding into the network.

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[*] By Louis A. Ferguson, Superintendent, Chicago Edison Co.

The total current furnished to the system at the time of maximum load in the winter of 1897 was 50,730 amperes, and the total low-tension direct-current kilo-watt hours output for the stations for the fiscal year of 1897 was 15,255,466.

From Station No. 1, one of the four central stations, to the Adams St. sub-station is laid an immense trunk line known as the Adams St. trunk line, having a total cross-sectional area of 66,000,000 circular mils, 28,500,000 circular mils being ordinarily connected on the positive and negative sides and 9,000,000 circular mils in the neutral. The length of this trunk line is 3,340 ft., and it is made up of 15 special Edison tubes, each 3,000,000 circular mils area, laid directly in the ground, and 14 stranded rubber insulated, lead-covered and juted cables, each of 1,500,000 circular mils area, drawn into cement-lined iron dusts. The trunk line, on leaving Station No. 1, goes down a shaft 60 ft., thence through a brick tunnel built especially for it in the river bed to the east side, where it rises again in another shaft 60 ft. into the tunnel house, where a small switchboard is located. The portion of the trunk line in the shafts and tunnel, which is 430 ft. in length, is made up entirely of cables; of these, 45 are 1,000,000 circular mils, and 14 are 1,500,000 circular mils submarine cables, each supported on iron racks; each of the tubes and cables is provided with an ammeter at Station No. 1, and with switches at both ends, so that they may be completely disconnected from the system in case of trouble. Two of the 3,000,000 circular mils tubes are provided with throwover switches and arranged so that they may be quickly connected either to the positive or neutral or negative or neutral at will. All of the cables are provided with throwover switches on both ends, so that they may be operated either as positive or negative at will, thus providing for any possible contingency that may arise. At the Adams St. sub-station the trunk line feeds into the main bus-bar in the distribution room, and from the switchboard 42 feeders radiate to various points in the business district, ranging in size from 250,000 circular mils to 1,000,000 circular mils, and in length from 290 ft. to 2,831 ft., the average size being 485,000 circular mils, and the average length of feeder 1,373 ft.

The maximum current in amperes carried over the trunk line and distributed from the Adams St. sub-station last December was 34,400 amperes, the maximum loss of pressure on the trunk line being 12.4%, and to the customers' meter 22.8%, the distance to farthest feeder end being 6,171 ft.

(A rather full description of the several generating stations and feeder systems of the Chicago Edison Co. was given which we omit, as it is not clear without diagrams.—Ed.)

Uniformity of pressure throughout an incandescent electric lighting system is absolutely essential to commercial success.

The only economical and safe way to regulate in a city where the distances are not abnormally great, and where the load is fairly well distributed, is to so design the conducting system that it will be self-regulating; that is, so that it will require no change of the resistance of feeders or anything of the kind. A good conducting system should have an ample number of feeders reasonably close together, and the connecting mains should be of generous cross sectional area.

A valuable adjunct to a station; where there are one or two straggling feeders of great length so located that they cannot be interconnected with the general system so that they may be benefited by such connection, is what is known as the "Booster." This is a direct-current dynamo wound for a large current and low voltage, and is used for raising the pressure of any of the main feeders which are ordinarily low. The "Booster" dynamo should be series wound and so designed that its voltage will be proportional to the current passing through it, the speed remaining constant. It is connected in series with the feeder, whose pressure is to be raised, and is belted to or directly connected with a motor which drives it at the speed for which it is designed. As the load on the feeder increases, the electromotive force of the "Booster" dynamo increases proportionately, and adds to that of the feeder, thus overcoming the loss of pressure due to the increased current in the feeder, which enables the feeder to deliver the proper pressure at its mains.

In some central stations two or more potentials or pressures are used, certain dynamos working on a bus-bar at one pressure and the other dynamos working on another bus-bar at different pressures. This method is only economical when the dynamos can be worked very near the maximum load, which is not often the case. In some cities the dynamos in central stations or machinery or storage batteries in sub-stations feed into one general system at different points, each station or sub-station operating at such pressure as will deliver the same voltage at the feeder end of the mains. This is, without doubt, the method to be recommended as giving the best efficiency and assuring reliability of service throughout the system. With the method proposed, in case of accident to any one station, either by fire or lack of water supply, the whole system will not be shut down, because each station will take a share of the load carried by the now disabled station.

The maintenance of good pressure regulation at the customer's meter is very much more easily effected with an interconnected direct-current distribution such as has been described, than with the ordinary alternating current central station system, such as has been exploited in this country. Owing to the parallel operating of direct-current dynamos and distribution systems fluctuations of the pressure, due to changing over from one machine to another, so prevalent in the ordinary American alternating current central station, and so annoying to customers, do not occur, and a carefully operated direct-current central station should show an average deviation from the mean of less than one volt.

One of the advantages to be derived from the use of direct-current distribution as distinct from alternating-current distribution, is the employment of storage batteries. They may be adopted for use in various ways: (1) in sub-stations in outlying districts where the load factor of the district is very small; (2) in the central stations themselves to deliver the entire output during period of minimum load; (3) at the centers of distribution for discharging during the peak; (4) as auxiliaries in rotary transformer sub-stations for discharge use at the time of the maximum load in the main central station. In addition to these various ways in which the battery may be employed, it always acts as a reserve, guaranteeing the consumer good service, in much the same manner as a bank surplus is a guaranty to the depositors in cases of financial emergency.

Storage batteries when installed in central stations or centers of distribution are usually connected to the main bus and allowed to float on the system taking a charging current from the bus or discharging into the bus according to the load on the system, the generating units being worked at such loads as will insure the best efficiency of the entire system.

Batteries are economically valuable in connection with the distribution of direct-current in systems whose load curve has an average peak width of not more than two hours, since the investment required for storage batteries to carry the peak having an average width of less than two hours is less than the investment required in steam and electrical machinery to do the same work. The storage battery also has the same value that exists in the case of moving machinery as a reserve in meeting sudden increases of load, provided such increase of load does not continue for a sufficient period to wholly discharge the battery and insufficient time remain for recharging before the ordinary load peak of the system appears at the regularly appointed time. Such a condition is rarely, and, I might say, almost never met with, although at times this condition may be approached.

The steam and electrical machinery is rated by the horse-power or kilo-watt, and the duration of the load peak does not influence the value of the investment since the machinery may be operated for the full 24 hours at its maximum capacity. The storage battery, however, is rated by the horse-power hour or kilo-watt hour, and the investment is nearly or directly proportional to the number of hours during which it discharges the maximum capacity, so that if we required the battery to be prepared to carry the full peak prolonged for seven or eight hours every day, the investment in battery would be enormous as compared with steam and electrical machinery to furnish the same kilo-watt hours output.

The storage battery has a very distinct value, which is seldom recognized and employed to its full advantage, when located at the central distributing point of a system with feeders radiating to various points in the network. The battery may be provided with two or more end cell switches, so arranged that they may be connected in multiple and feed into the main distributing feeder bus, or they may connect also to one or more auxiliary bus-bars with a different number of cells in series, feeding into each bus, thus providing two or more potentials at the center of distribution. In this way the long feeders may be connected during the time of maximum load to the auxiliary bus or buses and additional current forced over them, utilizing their full capacity and maintaining a uniform feeder end pressure by means of an investment in end cells very slight as compared with the investment in additional feeders and mains required to accomplish the same result.

The direct-current distribution system is very much better adapted to electric elevator work than the alternating current-distribution, and, as far as I am able to learn, there has not yet been developed a commercially successful direct coupled electric elevator capable of running at varying speeds and operated by alternating currents.

The direct-connected electric elevator is a piece of apparatus which is of the greatest value to the central station companies, since it is practically the key to the isolated plant situation, and with its aid we are enabled in a large percentage of instances to show to the owners of large mercantile establishments and buildings a decided saving in the purchasing from the central station company of electricity for lighting, elevator and general power service as compared with the cost of operating an isolated plant, using hydraulic elevators. The immense advantage to the central station companies in being able to supply commercially successful electric elevator service economically, may be realized when we consider that there is connected to the systems of the Edison companies in New York, Boston, Brooklyn and Chicago 15,000-HP. capacity in direct-connected elevators, representing a gross income of approximately $375,000 annually. At the present time alternating-current distributing systems confine us to the use of continuous running motors belted or geared to the elevator pump or winding equipment; but such an arrangement is not fitted for first-class passenger service and is very uneconomical, and similar equipments using direct-current motors were in use ten years ago and have long since become obsolete and have been entirely superseded by the direct coupled electric elevator which operates for approximately one-half the cost.

The use of low-tension constant potential arc lamps connected in multiple to the distribution system has made rapid strides during the past three years, and in New York, Brooklyn, Boston, Chicago and other cities is fast superseding the use of series arc lamps wherever the low-tension mains operate, and the day is not far distant when series arc lamps will be employed only in the outlying districts where there is not sufficient business to warrant the extension of the low-tension distribution system. The competition effected by the Welsbach gas burner has done much to develop the constant potential arc lamp, and it is safe to say that with incandescent lighting alone the central station companies are rendered helpless against the improved gas burners; but a successful competitor has been found in the use of the 3½ ampere direct-current enclosed arc lamp. Although very much has been done in the last year in the development of the large alternating current arc lamp, it is still far from being in the state of perfection, and cannot be said to compare practically or economically with the constant potential direct-current enclosed arc lamp.

It seems to the writer that the useful field of operation for alternating-current distribution system is not in large cities, but rather in the scattered suburban residence districts and small towns where commercial lighting, elevator service and general power distribution forms an insignificant portion of the demand and where the first cost of the direct-current installation would so far exceed that of the alternating-current system of distribution with primary mains and large transformers for blocks of lighting as to make the interest charges so great that the property would be rendered unremunerative.

The successful central station company of the future will be, as outlined in my paper read before the Association of Edison Illuminating Companies, at its last convention, the one combining intelligently the use of alternating and direct currents, employing direct current in the distribution system in the thickly settled business and residence districts of a city and alternating current for the distribution systems in the scattered residence districts and surrounding suburbs. The energy will be generated at one or two large condensing stations located where water and fuel may be obtained at the minimum cost and the energy transmitted to the various sub-stations located at the electrical centers of the distribution systems. The choice of low-pressure direct-current or high-pressure alternating-current for the transmission to the sub-stations will depend upon their relative distance from the generating stations, rotary transformers or other forms of current rectifiers being employed in the sub-stations which supply the direct-current distribution networks when alternating currents are used for the transmission.

Distribution by Alternating Currents.*

Ever since the installation of the first few pioneer alternating-current central stations, just ten years ago, we have heard it predicted that for the distribution of current for lighting from central stations direct-current was a thing of the past, and that in a few years the alternating-current transformer system would hold the field without a competitor. The great success achieved in the transmission of power by polyphase alternating currents in the last three years has strengthened this general belief.

Investigation, however, shows that while in point of number the alternating-current stations, reaching into the thousands, completely overshadow those of direct-current, there are few really large stations, outside of water-power plants, that are to-day employing alternating currents for distribution, and that while enormous investments have been made in direct-current stations in our larger cities, camparatively small amounts have been invested in alternating-current work.

The alternating system was heralded as providing a means of distribution with a great reduction in first cost of plant, and for years the development of the system has been made with this the principal end in view. On the other hand, direct-current distribution in the form of the Edison three-wire system has been steadily and intelligently developed to the highest standard of economy of operation, simplicity and permanence. In the same city, alternating-current stations have not, as a rule, been successful in competition with three-wire stations; their service has not been as good, and their profits have been smaller.

I may startle many by stating frankly the discouraging fact, which has been barely whispered at times, that, judged by the standards of the magnificent Edison properties in many of our larger cities, few alternating-current central stations in the United States have been a success. The fault lies, not with the alternating current itself, but with its application. Its few inherent deficiencies, such as the difficulties of operating motors and arc lamps, have been shown to have been only awaiting discovery and the solutions were at our disposal almost as soon as these important divisions of central-station service were operated with success from the Edison three-wire system. These can, therefore, hardly be held responsible for the difference in the commercial results obtained with the two systems.

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*By Herbert A. Wagner, Superintendent, Missouri Edison Electric Co., St. Louis, Mo.

The ends in view in the development of the two systems have been radically different. The one was to produce a given amount of light for the minimum of investment; the other was to provide a permanent investment that would render the maximum of profit. These standpoints in general mark the difference between the manufacturer and the user, and we find these two systems developed in this way—one almost entirely by the manufacturer, and the other by the combined efforts of the various users. The results are the natural effects of progression along these lines.

The early alternating-current stations were installed on the principle that the drop in lines with distribution at 1,000 volts was so small that it was practically negligible. Two wires were accordingly run out from the station, passing along those streets where light was to be furnished, and lights were connected at any desired points between the station and the farthest end, without reference to such trifling considerations as difference in potential. Distribution was attempted in this way for years, and in many places is still in operation. Lines are even being constructed to-day without any notion of a system of feeders and mains, although an almost perfect system for the maintenance of uniform pressure was in operation in many Edison stations before the first alternating station was in existence. Fortunately for the operators of such models of simplicity, the current delivered has usually been so small in quantity that with the proverbial No. 6 wire, which seemed to possess virtues not affected by distances, the difference of pressure between neighboring customers rarely exceeded 10%.

One alternating current station of which I have intimate knowledge, has used pressure wires in connection with each feeder for years. There may be a few others, but they are rare exceptions even to-day.

The usual system of distribution provides a separate transformer for each customer. In many cases, this implies the use of a very small transformer. It is impossible to make the efficiency of small transformers high. As each customer may at times use all of his lamps, he must have full transformer capacity for such an emergency. The ordinary ratio between maximum station loads and the number of lamps connected, is in most cases under 50% where meters are employed. The transformers then being of a total capacity equal to the number of lamps connected, average at best only 50% of their rated capacity at the maximum station load. In most stations the average load generated is much less than 25% of the maximum load, and, therefore, with twice the transformer capacity of that represented by maximum station load, the average transformer load would not exceed 10% of the transformer capacity, all the year round.

The efficiency of the average modern transformer of usual size at 10% of its rated load is not over 65%, and the average of transformers at present in use not more than 50%. It is perfectly safe to say that there is not an alternating-current station to-day using individual transformers for each or neighboring customers that can show an average efficiency of distribution of over 60%, and few that can show over 50%.

In Europe it is, to some extent, the practice to use transformer sub-stations with low-potential distribution from these points. Transformers are cut in and out at these sub-stations by attendants according to the demand for current. It is doubtful if, after paying interest on the investment of property and housing for these transformer stations, together with the investment in instruments and switches required, and the attendants' wages, there is very much saving effected. Had we nothing better to turn to than these systems, the cost of distribution from large stations would be extreme compared with the direct-current, Edison three-wire system, and competition with the latter could not be a success.

Another very important consideration is the economy or efficiency of lamps used. To employ successfully the highest-economy lamp made, a very uniform pressure must be maintained. With the usual alternating-current system, and with an equally good disposition of feeders and mains, the variations of pressure will exceed those in a direct-current system by nearly 3%, on account of the transformer drop, and to secure even this limit of variation, pressure wires must be used with each feeder. It is not surprising to find, therefore, that almost all alternating-current stations are using lamps requiring 20% more current than those used by direct-current stations.

We are satisfied that at the present time the Edison three-wire system of distribution is the most efficient in use and the most nearly perfect in details. We know that the usual system employed with alternating current is not efficient, and does not admit of as close regulation, but it is vastly cheaper to install.

Comparing the cost of individual transformers and high-potential distributing mains with the three-wire system of mains at low potential, we do not find a great difference in first cost in favor of the alternating. We do find, however, that the Edison feeders for the same distance cost about 31 times as much as for alternating current at 1,100 volts, 125 times as much at 2,200 volts, or 500 times as much at 4,400 volts. It would then appear that if we could apply alternating current to the feeders at high potential and transform down for the mains, we might reach the lower first cost of the ordinary alternating-current system and possibly retain all the best features of the direct current. To accomplish the former, the transformers must be provided at a small proportion of the cost of the alternating-current feeder, and to do the latter, they must not increase the average losses in the system. It is obvious that we could with alternating current move our station to any reasonable distance from our center of distribution, and at comparatively small additional cost for feeders. The whole problem then seems to come down to transformer efficiency and means of regulation.

To consider the matter of regulation first. We see at a glance that we cannot use the direct-current method of regulation by supplementary bus-bars, but we can use the booster method; and can, moreover, apply a static booster to each feeder to regulate within any desired limits and with as small gradations as necessary.

Now, to return to the transformer itself and its efficiency. It is evident that, with this system, the transformer capacity need be no greater than that required for maximum station load, instead of more than twice that amount or nearly equal to that required for the total number of lamps connected. This at once doubles the average load on our transformers and raises the average efficiency. It also incidentally reduces the first cost of transformers in still greater proportion.

We have thus eliminated the features in which the ordinary alternating-current system of distribution has been inferior to the direct current, and have provided means for obtaining better regulation and higher efficiency at a very much less cost of installation than with the direct-current system.

This system was conceived several years ago, and it has since been my good fortune to have an opportunity to install a system of this kind on a large scale, which is now in very satisfactory operation. It is laid out exactly as a three-wire Edison system would be, except that there are no sub-feeders. A network of mains is planned as if for use with direct current. The feeders are all designed for 110 kilo-watt maximum load at 1,100 volts, and at each feeder end is placed a 110 kilo-watt transformer feeding into the three-wire network in the same manner and at the same points as with the direct-current system. The transformers are located in manholes of suitable design. From the secondary terminals of each transformer, pressure wires are run back to the station. Each feeder has an independent regulator by which the pressure can be raised or lowered. There are no primary mains, nor any connection whatever between the primary feeders. The regulators perform two functions. They are used to maintain the proper pressure as indicated by the volt meters and also to divide the load between transformers in any way desired as indicated by the feeder ammeters. It is possible to shift the entire load from one transformer and feeder to an adjacent transformer in this way without sensibly affecting the pressure on the system, and an equal division of load between transformers can be readily maintained at all times if desired. This is a very important consideration when very heavy loads or overloads are to be carried.

Several large three-wire, direct-current Edison stations are beginning to employ alternating current to extend their lighting territory beyond that possible or profitable with low-tension current. This is a recognition of alternating current which would not have been considered for a moment a few years ago. They now propose to use alternating current to transmit their energy at high potential to a distant sub-station, where it will be transformed to a lower pressure and then again transformed by means of rotary transformers to direct current, which is in turn distributed over the three-wire Edison system as if generated in the ordinary way. This is a very beautiful and instructive application of alternating currents, and ingeniously designed machinery. It gives the manufacturers a chance to sell additional machinery, swells the company's real estate investment and gives work to the unemployed to operate the sub-stations.

The loss in the conversion to alternating current and back is about 15% in addition to the loss in static transformers and lines. This distribution might be accomplished without the additional machinery, wire, real estate, labor, and loss in efficiency.

A much higher efficiency of distribution, and better regulation, could be secured by using the alternating-current system as it is, without transformation to direct current, and everything could be controlled from the main station without employing labor or apparatus at sub-stations.

The greatest argument used against alternating current used to be that it would not run a motor. It was long ago proved that it can, and that without a commutator. This subject now brings us to multiphase systems. There are two of these systems in general use, the two-phase and the three-phase. Other systems are but modifications of these and will be mentioned as such. Motors can be operated with equal facility and efficiency on either system and have many distinct advantages over direct-current motors. We can now obtain single-phase motors which equal the multiphase and direct-current motors in efficiency and almost all desirable points. They start readily with load and may be operated with variable speed. In fact, they equal the direct-current shunt motor in all points, excelling it in efficiency and simplicity.

We can meet the direct-current advocates on the power question, therefore, on at least an equal footing, save only one application met in central-station practice; namely, the operation of high-speed elevators. The alternating-current motor, multiphase or single-phase, cannot be controlled for this work as readily as a compound series, direct-current motor. It has taken several years, however, to perfect the mechanism for the control of direct-current elevator motors. Give us the same time, and we will do it with alternating current. This field for power has only of late been opened to direct-current stations, and it is yet a question for debate as to whether it is a paying one.

We now come to the direct-current advocate's last and greatest stronghold, the use of storage batteries. We may ask first whether storage batteries have yet been proved to be a valuable adjunct to the central station, cost and maintenance considered. It is true they are being tried by several large stations, and we watch eagerly for the results. They equalize the station load to a greater or less degree, and cut down the generator capacity for the peak. Are they, however, cheaper than generators, engines and boilers of the same capacity? Are the losses in transformation less than the cost of a few more attendants? Is their maintenance less expensive than that of the generating apparatus? These questions cannot as yet be answered in the affirmative. But if the battery man's most sanguine hopes be realized, what then? If rotary transformers are good enough for the direct-current man to use to change the direct current to alternating current, transmit a good proportion of his load to a distance and transform again to direct current, why should not the alternating-current man use them to charge his batteries and then to transform their output back to his pet form of current? The loss in transformation is not any more than with our contemporaries' long-distance transmission system, and, in this instance, they are small and unimportant, we are told. There is at least one station in the country where storage batteries are being used in this way, and, I believe, with success, as storage batteries go.

Arc lamps have been familiar to us on alternating-current circuits for some time, and the alternating current, enclosed, long-burning arcs are now numbered by the thousands. Street lighting is still, however, in most places done on the direct-current series system, and even the largest machines yet built for this purpose are very small in comparison with our large direct-connected generators.

The great desideratum in central-station practice is to be able to employ one system for everything. All current for all classes of service should be supplied from but one type of generator, be this direct current or alternating current. In this way, only, can the maximum output be accomplished from a given investment in machinery and apparatus, and the greatest economy in operation secured. This has been accomplished in many stations where a limited range of service is to be provided. Arc lighting has, of all, been the most troublesome to provide for. How shall we operate our arc lamps from our incandescent lighting system, has been the anxious inquiry. The constant-potential arc lamp has answered this question for commercial lighting, but city street lighting cannot be so easily provided for. The Edison companies have done a limited amount of this from their three-wire system, but this can be done to advantage only in districts where mains have been provided for commercial lighting. For extended arc lighting, the small series machine with its belts and clutch pulleys still holds the fort.

I am able to state, however, that one large company has recently solved the problem to its entire satisfaction. This company furnishes 2,600 street lamps to the city, lighting some 300 miles of street. These were operated by a small army of series arc machines.. They were installed by a company that was acquired by purchase by the one first mentioned. As this company had long since adopted alternating current for its entire distribution, it was extremely desirable to be able to operate these city lamps from its large direct-connected alternators, thereby saving in fuel, attendance, floor space and reserve investment

After a few months trial of an experimental circuit with alternating current, it was found perfectly feasible to operate the same direct-current lamps, slightly remodeled, on the same circuits of sixty or eighty lamps in series. A system of this kind was, therefore, adopted and the company now has 2,300 of these lamps in regular operation by alternating current in this way. The circuits are each provided at the station with a regular step-up transformer of a maximum capacity of 4,000 volts and ten amperes, and the feeders to these transformers are treated on the switchboard in the same way as the feeders for incandescent lighting. It is quite usual for one generator to carry 2,000 of these lamps. The lighting is satisfactory to the city and the lamps give better service than when operated by direct current. There has been a very marked saving in fuel and attendance. The indicated horse power per arc lamp is considerably less than with the direct-current arc lamps operated in the usual manner.

I know of no other place where this is being done, and it stands as a very pronounced example of the flexibility and adaptability of alternating currents.

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SOME NOVELTIES IN SWING BRIDGE CONSTRUCTION ON THE TRENT VALLEY CANAL.

By R. B. Woodworth.*

The Trent Valley Canal, now in process of construction by the Dominion of Canada, is projected to extend from Georgian Bay through the province of Ontario to Lake Ontario, and is expected to be of great public value as a waterway. Its construction has naturally demanded numerous high-level and swing bridges. Several of these were erected during the past year by the Central Bridge & Engineering Co., of Peterborough, Ont., and the purpose of the present paper is to describe certain peculiarities in the construction of the two more important of these, in the design and detail of which the present writer was directly interested.

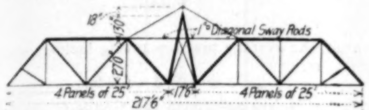

Fig. 1.—Grand Trunk Railway Bridge Across the Trent Valley Canal at Nassau, Ont.
Central Bridge & Engineering Co., Peterborough, Ont., Builders.

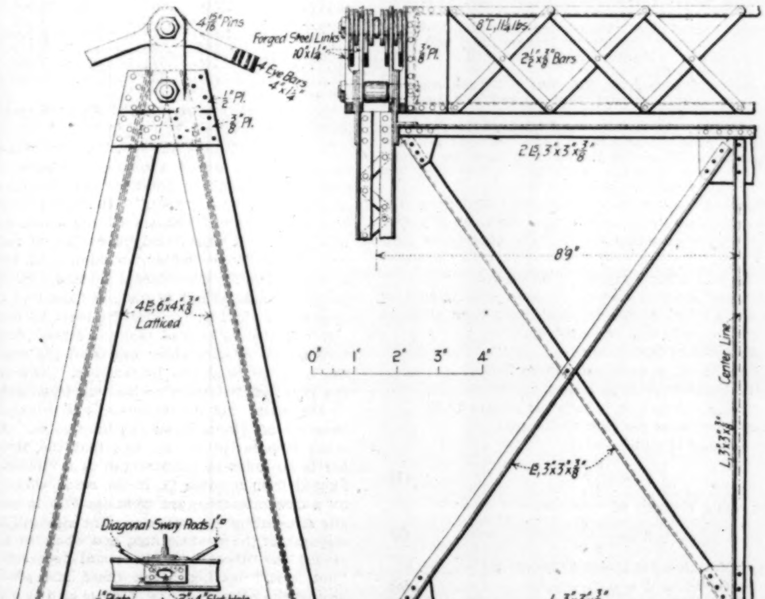

FIG. 2.—CENTER TOWER CONSTRUCTION FOR GRAND TRUNK RY. BRIDGE OVER THE TRENT VALLEY CANAL.

These were the swing bridges to carry the Grand Trunk Ry. over the canal at Nassau, Ont., and the Canadian Pacific R. R., over the canal at Ashburnham, Ont. The former had a clear span of 217½ ft. c. to c. of end lifts, and the latter a span of 187 ft. c. to c. of end lifts. Both were of the same general design, riveted lattice trusses with minor differences due to the different lengths of span, and the idiosyncracies of the men who framed the new Canadian tariff. When the material for the long span was ordered angles were most economical; when we came to detail the short span the tariff had made it preferable to use channels. Both were figured for the loadings given under class II. of the 1896 specifications of the Department of Railways and Canals, viz.: the dead load of the spans themselves, cross ties, rails, etc., at 500 lbs. per lin. ft. of span, and a rolling load of two 112-ton locomotives with a uniform train load of 3,000 lbs. per lin. ft. For the longer span this gives a loading on the turntable, when the bridge is swinging, of about 800,000 lbs. The general style of construction is shown in the diagram, Fig. 1, and need not detain us except to say that all connections were riveted with the exception of the top laterals and the pin connections for the eye-bars and sway-rods connecting the trusses to the central tower. The peculiarities of the construction were three: The turntable center, the central tower, and the end lifts. The design of the latter is the especial property of Mr. W. H. Law, at that time the engineer and manager of the company. The device is based on the use of the toggle-joint, is very simple to construct, and most effective in operation.

Central Tower.—In most swing bridges of ordinary types, whether rim or center bearing, we have to do in the ultimate analysis with beams of complete or partial continuity, and have to take care of shearing stresses transmitted across pivot or drum, and provide special devices to prevent hammering of the truss ends. In the bridge under consideration the rolling load can produce stresses only in the span on which it may be; and the trusses when closed may be figured as simple spans resting on their own supports and completely discontinuous. The turntable is surmounted by a braced tower, Fig. 2, on which rests forged steel links turning on 4 15-16-in. pins, and themselves carrying similar pins to receive the ends of the eye-bars. When the bridge is closed these eye-bars can receive no stress; when the bridge swings, the trusses are simply hung by them to the central tower—a form of construction most simple, effective and economical, easily computed and most practicable in the shop.

It is quite possible, of course, that by some accident or other—a knock from a boat, say—the links at the top of the tower might be drawn over so far to one side as to fail to return to their normal position when the bridge is swung back to its position when closed. To obviate any mishap of this kind, diagonal sway rods 1 in. square are introduced extending from the pins at the hip to the central tower. Here they connect to 2-in. pins which travel in slotted holes 4 ins. in length, giving each pin a movement of 1 in. each way from the center. These rods only come into play in the case of accident to the links, and are emergency safeguards and wind braces.

The central portal is double, as shown; one set of bracing acting with the links, the other set giving rigidity to the tower; the whole forming very efficient protection against accidents common to canals as well as against high winds.

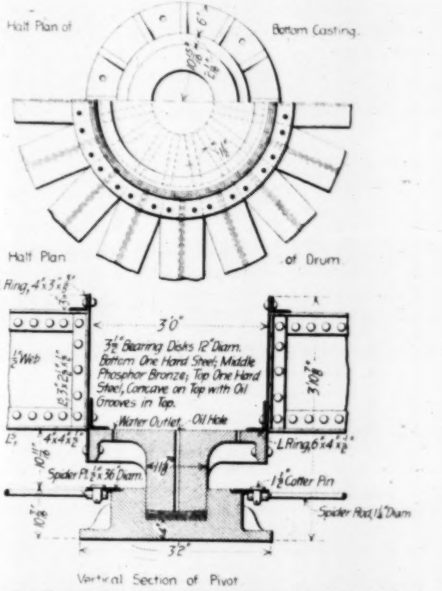
Half Plan of Bottom Casting.
10 15/16"
6'
1 1/2"
Half Plan of Drum
L Ring, 4"x3"x3/8"
3'0"
3 1/2" Bearing Disks 12" Diam. Bottom One Hard Steel; Middle Phosphor Bronze; Top One Hard Steel, Concave on Top with Oil Grooves in Top.
1/2" Web
2 Ls, 3"x2 1/2"x1/2"
3'10 7/8"
Water Outlet
Oil Hole
Ls, 4"x4"x1/2"
L Ring, 6"x4"x1/2"
10 11/16"
Spider Pl. 1/2"x36" Diam.
1 1/8"
1 1/2" Cotter Pin
Spider Rod, 1 1/4" Diam.
10 7/8"
3'2"
Vertical Section of Pivot

Fig. 3.—Turntable and Center Pivot Construction for Grand Trunk Ry. Bridge Over Trent Valley Canal.

Turntable Center.—This was designed for the express purpose of reducing shop cost by keeping the radial girders of full depth throughout their length. The load from the bridge is delivered to the drum by 16 radial girders which receive it from 8 bearing beams—that is, from 8 points of support. The turntable is combined rim and center bearing—and 250,000 lbs. reach the center, while 550,000 lbs. go to the 36 rollers. The center, Fig. 3, of cast-iron or steel, terminates in its own pin, and the form of construction reduces somewhat the amount of power required to turn the bridge; with this additional feature that the necessity of using bolts is entirely done away. The steel center plate was riveted to the cast-iron center in the shop and the field riveting was then easily done without any special danger to the center.

The whole structure as thus designed merits attention from the manufacturer's standpoint, and its description may be of use in the further perfecting of shop detail, most centers being an outgrowth from the design of locomotive turntables, while this is an original creation out of hand.

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*Draftsman, Carnegie Steel Co., Pittsburg, Pa.

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EXPERIMENTS ON CAST-IRON CYLINDERS.*

By C. H. Benjamin, M. Am. Soc. M. E.†

For several years past the writer has been conducting a series of experiments to determine the bursting strength of cast-iron cylinders under water pressure. The cylinders used were cast by the Taylor & Boggis Foundry Co., of Cleveland, from a special foundry mixture, such as they ordinarily use for water and steam cylinders. The metal showed a fine gray fracture and a surface close and free from holes. The cylinders were cast on end and without the use of chaplets for the cores. Test pieces cast from the same iron showed a tensile strength of about 24,000 lbs. per sq. in., and a modulus of rupture of about 35,000 lbs. under a transverse load.

It may be noted, however, that the first three cylinders tested (a, b and c in Table I.) were of common foundry iron, having a tensile strength of about 18,000 lbs.

The cylinders were of three sizes, 6, 9 and 12 ins. internal diameter, and of lengths approximately twice the diameters.

The flanges and heads were made of extra thickness that the rupture might always occur in the shell of the cylinder. Fig. 1 and Table I. show the proportions and dimensions of the various cylinders tested.

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*Condensed from a paper presented at the Niagara Falls meeting of the American Society of Mechanical Engineers.

†Professor of Mechanical Engineering, Case School of Applied Science, Cleveland, O.

TABLE I.—Dimensions of Cylinders. (See Fig. 1.)

No.	A	B	C	D	E	Depth counter-bore.	G	H	I	K	No. of bolts, each head.
a	12.16	26.05	0.70	16.25	.....	....	1.07	1.12	1.0	..	24
b	6.16	17.95	.60	13.06	.....	....	1.09	.70	1.0	..	16
c	6.09	12.19	.50	10.05	.....	....	1.12	.70	1.0	..	8
d	12.45	26.5	.56	16.21	13.25	0.12	1.75	1.35	1.5	..	24
e	9.12	19.0	.61	12.96	10.08	.11	1.5	1.25	1.25	..	16
f	6.12	13.0	.65	10.02	7.08	.11	1.25	1.00	1.25	..	8
1	9.58	18⅞	.402	13.33	10.83	⅛	1 13-16	1⅛	1⅝	11⅝	16
2	9.375	18⅞	.573	13.13	10.63	⅛	1 13-16	1⅛	1⅝	11⅝	16
3	9.13	18⅞	.596	12.88	10.38	⅛	1 13-16	1⅛	1⅝	11⅝	16
4	12.53	25¾	.571	16.4	13.34	⅛	1.34	1½	15-16	14⅝	24
5	12.56	25⅝	.531	16.56	13.56	⅛	1.34	1 9-16	15-16	14⅝	24
6	12.16	25⅝	.93	16.22	13.41	⅛	1.18	1⅛	15-16	14⅝	24

Note.—The rough dimensions in this table are averages from a number of measurements.

The cylinders are arranged in the table in the order in which they were tested. Those marked a to f were broken in the winters of 1895-6, and the remaining six during the succeeding winter.

The cylinders were bored in such a way as to insure a practically uniform thickness in each shell, and the flanges were faced and counterbored. Steel bolts, having a tensile strength of about 80,000 lbs. per sq. in., were used to fasten on the heads, in such numbers as to give an excess of strength and to prevent leakage.

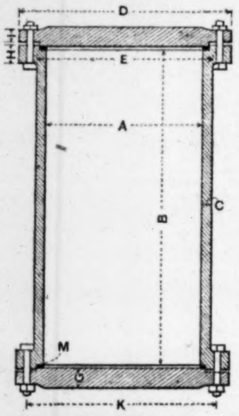

Fig. 1.—Form of Cast-Iron Cylinders Burst by Internal Pressure.

A single-acting plunger pump, with a plunger ⅞-in. in diameter was used for raising the pressure, being connected to the head of the cylinder by extra heavy iron pipe with bronze fittings.

Little trouble was experienced with the pump itself. It was found, however, almost impossible to obtain any check valves which would work satisfactorily at the high pressures. Numerous types of valves were tried, swing check and drop check, metallic face and rubber face, but they all leaked. Either minute particles of dirt would get under the valves or the slip would be so great as to forbid increase of pressure beyond a certain point. We finally overcame the difficulty in a measure by using two valves on each side of the pump.

To determine the pressure we used a Crosby hydrostatic gage, graduated to 2,000 lbs., located on the pipe close to the cylinder. Before testing, each cylinder was calipered inside at six different points, three measurements being taken in each of two meridian planes at right angles to each other. The deformations as thus measured were very slight, ranging from 0.004 to 0.012-in., but no law could be determined.

Each cylinder was carefully examined for flaws of any description. If any small blow-holes were found they were filled with lead or tin hammered in, and then the surface was covered with a coating of paraffine. The cylinders were as free from flaws as could be expected.

Of all the difficulties encountered the most serious was that of finding any satisfactory packing for the heads of the cylinders. We tried successively brass wire gauze filled with soap, copper wire, lead wire, soft rubber with graphite and vulcanized rubber. The metal gaskets all failed on account of their lack of elasticity. Although tight at the lower pressures, being compressed by the bolts until the soft metal was squeezed into every irregularity of the cast-iron surface, they failed to respond when the bolts were stretched by the water pressure, and the water would run through in streams.

This fact is interesting as showing that the initial tension caused by screwing up the nuts has no effect on the tension under pressure when a non-elastic gasket is used. The tensile strength of the bolts used in these experiments was much in excess of the strength of the cylinder, and yet, under the comparatively low pressure of 400 to 600 lbs. per sq. in., the bolts stretched enough to practically relieve the reaction of the gasket. The elastic rubber gaskets failed principally on account of weakness, usually blowing out as the pressure was increased. Vulcanizing by heat made them stronger, but less elastic. We then counterbored the cylinders to a depth of about ⅛-in., as shown in Fig. 1, fitted a circular projection on the head closely to the counterbore, and introduced a gasket made of straw-board soaked in boiled linseed oil, and allowed to stand several hours before being put in position.

Another serious difficulty was encountered in the presence of minute blow-holes in the shell of the cylinder. Some of these were almost invisible to the naked eye, but as the pressure rose the water would spurt in slender streams to a distance of several feet, in such quantity as to render further increase of pressure impossible. The only remedy in such cases was to peen the interior surface slightly with a round hammer and then coat it with paraffine. Even then the water would ooze from the iron at every pore as if it were in a violent perspiration.

Before beginning each experiment the air was forced out of the cylinder through a small vent at the top. The pressure was then gradually applied until rupture occurred. It was found impracticable to make any measurements of the exterior diameter during the test, the changes being so very minute.

The following is an abbreviated log of the experiments:

(a) Wire gauze packing; leaked at 400 lbs. Substituted copper wire No. 22, A. W. G.; this leaked at 600 lbs. Substituted soft rubber gasket; pressure carried to 800 lbs. several times. Leak at blow-holes stopped by peening. On raising pressure to 775 lbs. cylinder failed on a circumference just below the upper flange, the crack starting at blow-hole and running each way about 90°.

(b) Gasket of lead fuse wire; leakage at pressure of 450 lbs., and the flange cracked. Substituted rubber and graphite packing; leak at crack with pressure of 600 lbs; no further rupture.

(c) Rubber and graphite packing inserted, heated to 250° F. by live steam; bolts screwed down and packing left one day to harden. Leaked badly at 600 lbs.; renewed packing, leaked again at 550 lbs. Flanges showed signs of failure.

(d) Counterbored joint, with gasket of straw-board soaked in linseed oil. Leakage at blow-holes with 700 lbs. Blow-holes peened and coated with paraffine, pressure raised to 800 lbs. several times. One blow-hole calked on outside. At 700 lbs. rupture occurred on longitudinal line through blow-hole. Several small blow-holes found in line of fracture.

(e) On this and all subsequent cylinders the counterbore and straw-board gasket were used. Pressure raised gradually to 1,325 lbs., when rupture occurred on circumference under flange. The crack began at a point where there were several small blow-holes.

(f) Pressure raised gradually to about 2,500 lbs., when cylinder failed in same manner as preceding one; cylinder leaking badly at time of rupture.

No. 1. Broke at 600 lbs. on a longitudinal line along a row of blow-holes.

No. 2. Broke at 1,050 lbs. around a circumference just under flange. Fracture very clean.

No. 3. Broke at 975 lbs. in the same manner as No. 2, the crack beginning where there was a slight flaw. Fracture clean.

No. 4. A number of small blow-holes near the center of shell caused considerable trouble by leakage, and had to be calked inside and out. Rupture finally occurred at 700 lbs. along a longitudinal line.

No. 5. Rupture occurred at 875 lbs., a crack starting under the flange running part way around and then up through flange and head.

No. 6. At 475 lbs. the bottom head broke. On renewing this and raising pressure to 900 lbs., the top head failed in the same manner. These heads had been used for several cylinders, and were probably weakened. The test was abandoned at this point for lack of time.

Great pains were taken in casting these cylinders, and they may be considered good examples of cast-iron cylinders as made for engine or pump work. The blow-holes mentioned were most of them very minute and under ordinary circumstances would have remained unnoticed.

Before summarizing the results of these experiments we will notice some of the formulas which have been proposed for steam engine cylinders of cast-iron.

Let d = diameter of bore in inches.
p = pressure in pounds per square inch.
t = thickness of shell in inches.
s = tensile strength in pounds per square inch.

The ordinary formulas for thin shells are:

For stress around circumferences:

$$S = \frac{p\,d}{2\,t}. \qquad (1)$$

For stress along element of cylinder:

$$S = \frac{p\,d}{4\,t}. \qquad (2)$$

Van Buren's formula for steam cylinders is:

$$0.0001\,p\,d + 0.15\,\sqrt{d}. \qquad (3)$$

A formula which the writer has developed in his "Notes on Machine Design," is somewhat similar to Van Buren's.

Let s' = tangential stress due to internal pressure, then by equation (1)

$$s' = \frac{p\,d}{2\,t}.$$

Let s'' be an additional tensile stress due to distortion of the circular section at any weak point.

Then if we regard one-half of the circular section as a beam fixed at A and B (Fig. 2), and assume the maximum bending moment as at C some weak point, the tensile stress on the outer fibers at C due to the bending will be proportional to $\frac{p\,d^2}{t^2}$ by the laws of flexure, or $s'' = \frac{c\,p\,d^2}{t^2}$ where c is some unknown constant.

The total tensile stress at C will then be:

$$S = s' + s'' = \frac{p\,d}{2\,t} + \frac{c\,p\,d^2}{t^2}.$$

Solving for c:

$$c = \frac{s\,t^2}{p\,d^2} - \frac{t}{2\,d} \qquad (a)$$

Solving for t:

$$t = \frac{p\,d}{4\,S} + \sqrt{\frac{c\,p\,d^2}{S} + \frac{p^2\,d^2}{16\,S^2}}. \qquad (4)$$

a form which reduces to that of equation (1) when c = 0.

An examination of several engine cylinders of standard manufacture shows values of c ranging from 0.03 to 0.10, with an average value: c = 0.06.

The formula proposed by Professor Barr, in his recent paper on "Current Practice in Engine Proportions,"* as representing the average practice among builders of low speed engines, is:

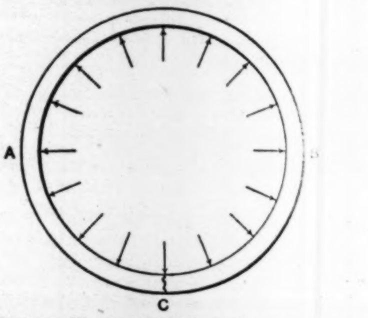

Fig. 2.—Diagram Illustrating Failure of Cylinder at a Weak Point.

$$t = 0.05\,d + 0.3\text{-in.} \qquad (5)$$

In Table II. are assembled the results of the various experiments for comparison. The values of S by formula (1) are calculated for each cylinder, and by formula (2) for all those which failed on a circumference. It will be noticed that six out of nine cylinders failed in the latter way. This appears to be due to two causes. In the first place, the influence of the flanges extended to the center of the cylinder, stiffening the shell, and preventing the splitting which would otherwise have occurred.

TABLE II.

No.	Diameter, d.	Pressure, p.	Thick, t.	Line of failure.	Formulas used. 1 $S = \frac{p\,d}{2\,t}$	2 $S = \frac{p\,d}{4\,t}$	a c =
a	12.16	800	.70	Circum.	6,940	3,470	0.046[1]
d	12.45	700	.56	Longl.	7,780	.....	.047[2]
e	9.12	1,325	.61	Circum.	9,900	4,950	.048[2]
f	6.12	2,500	.65	Circum.	11,800	5,900	.055[2]
1	9.58	600	.402	Longl.	7,150	.....	.049[2]
2	9.375	1,050	.573	Circum.	8,590	4,300	.055[2]
3	9.13	975	.596	Circum.	7,470	3,740	.072[2]
4	12.53	700	.571	Longl.	7,680	.....	.048[2]
5	12.56	875	.531	Circum.	10,350	5,180	.028[1]

[1] Strength of test bar, 18,000 lbs. [2] Strength of test bar, 24,000 lbs. Average of c = 0.05.

In the second place the fact that the flanges were thicker than the shell caused a zone of weakness near the flange due to shrinkage in cooling, and the presence of what founders call "a hot spot." In some of the cylinders this was quite apparent, the metal being porous and spongy near this point. It was found impossible to reduce the thickness of the flanges without making them too weak for the pressure [notice experiments (b) and (c)]. This would indicate the desirability of making flanges of the same thickness as the shell and reinforcing them by brackets.

It will also be noticed that the stress per square inch by formula (1) is only about one-third the tensile strength of the material as shown by test bar. This is partly due to the effect of distortion or bending from lack of uniformity in the metal and its thickness, but principally due to the presence of minute flaws and blow-holes. This is only another illustration of the fact that the strength of a test bar is no index of the strength of a casting. The stresses figured from formula (2) in the cases where the failure was on a circumference, are from one-fifth to one-sixth the tensile strength of the test bar. The strength of a chain is the strength of the weakest link, and when the tensile stress exceeded the strength of the metal near some blow-hole or "hot spot," tearing began there and gradually extended around the circumference. Values of c as given by equation (a) have been calculated for each cylinder, and agree very well except in numbers 3 and 5.

To the criticism that most of the cylinders did not fail by splitting, and that therefore formulas (a) and (4) are not applicable, the answer would be that the chances of failure in the two directions seem about equal, and consequently we may regard each cylinder as about to fail by splitting under the final pressure.

If we substitute the average value of c = 0.05, and a safe value of s = 2,000, formula (4) reduces to:

$$t = \frac{p\,d}{8{,}000} + \frac{d}{200}\sqrt{p + \frac{p^2}{1{,}600}}. \qquad (6)$$

Conclusions.

The conclusions which might fairly be drawn from these experiments would seem to be:

1. That cast-iron cylinders of the form ordinarily used for engines, when subjected to internal pressure are quite as likely to fail by tearing on a circumference as by splitting.
2. That by reason of local weaknesses and distortions the cylinder may fail when the stress, as calculated by the ordinary formula for thin shells is only about one-third of the strength shown by a test bar.

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*"Transactions" Am. Soc M. E., Vol. XVIII., p. 741, Eng. News, July 29, 1897.

3. That the principal cause of weakness is the sponginess of metal due to uneven cooling; that to insure good castings the flanges should not be materially thicker than the shell, the cylinders should be cast on end and suitable risers provided for the escape of dirt and gas.

4. That the proof of a pudding is in the eating, and the proof of a cylinder in the testing.

Discussion: Prof. Thomas Gray, of the Rose Polytechnic Institute, said that a very satisfactory way to pack the end joint of a hydraulic cylinder is to place a cup leather next the joint. With this every increase of pressure only forces the packing tighter. With the cylinder heads bolted to flanges cast on the barrel of the cylinder, the pull of the bolts tends not only to break off the flange, but to burst open the barrel of the cylinder just behind the flange. This would explain the breaking of several of the cylinders in the test around a circumference just back of the flange. This could be obviated by securing the cylinder heads by bolts running from end to end of the cylinder.

Mr. H. H. Suplee said that an actual cylinder casting has the valve-seat, ports, etc., cast on, which may have an important effect in strengthening or weakening the cylinders.

Professor Benjamin, in reply, said that the experiments were intended to throw light only on the strength of such cylinders as are used on ordinary slide-valve engines. It is intended to follow these by experiments on the strength of cylinders of such forms as are used in Corliss engines.

AN ELECTRICAL DEVICE FOR OPERATING HYDRAULIC VALVES AT A DISTANCE.

A variety of devices have been invented for opening and shutting valves at a distance. The accompanying illustrations show an electrical apparatus for this purpose invented, patented and made by Mr. Wm. Engberg, of St. Joseph, Mich.

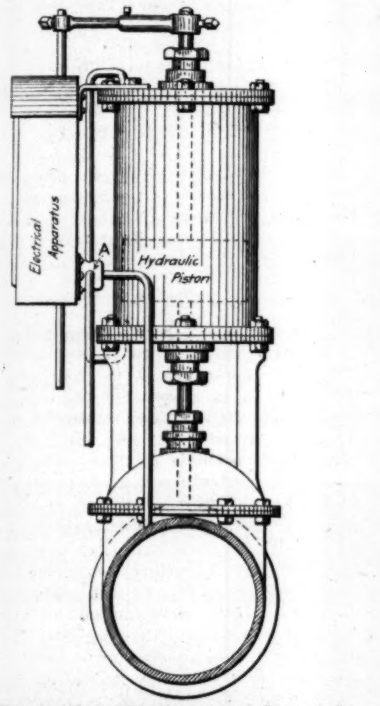

Fig. 1.—Electrical Controlling Apparatus Connected to Hydraulic Piston Operating a Gate Valve.

Fig. 1 shows a hydraulic piston mounted above and designed to operate an ordinary gate valve. At the left is the box containing the electrical apparatus which operates the small valve, A, which in turn admits water under pressure to either end of the piston, as desired. Fig. 2 is a front view of the electrical apparatus, with the door of the box containing it open. The small valve, A, is shown at the bottom, with a lever arm attached. The lever is operated by the dropping of one of the weighted bars, BB, which are held in place by dogs, as shown, until one of these is withdrawn by its corresponding magnet, C. The current reaches these magnets through the relays, just above, which in turn are connected by the proper wires with a switch-board at the pumping station or other point of operation. When the main valve is to be opened the circuit is closed at the operating station, the magnet acts upon the dog, thus releasing the bar, tripping the lever and turning the small valve so as to admit water beneath the piston. As the piston rises, the horizontal connecting rod, shown in Fig. 1, lifts the vertical rod passing through the box containing the electrical apparatus, which action through proper connections lifts the weighted bar into position again. When the main valve is to be closed the same procedure is followed as when opening it, except that the other weighted bar tips the lever, admitting water to the top of the piston and lowering the rod designed to bring the bar back to place. A gong bell on the switchboard begins to ring as soon as the valve begins to move, and in case of any accidental opening of the valve this bell will give the alarm at the main station.

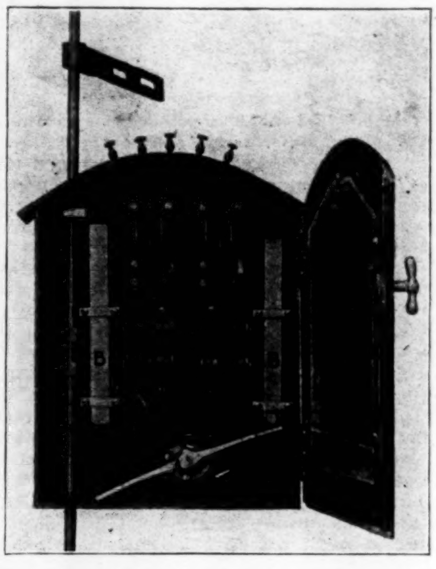

Fig. 2.—View of Electrical Controlling Apparatus.

Mr. Engberg states that twelve of these devices are now in use in different parts of the country, and that he is now patenting a device by means of which valves at a distance may be opened or closed varying degrees, as desired.

THE TWIN LAKES RESERVOIR, COLORADO.

By W. P. Hardesty.*

The Twin Lakes reservoir site has become one of the most noted ones in Colorado, both from its picturesque surroundings and attractiveness as a summer resort, and also from its being exceptionally well adapted for the conservation of water supplies. Twin Lakes are two beautiful sheets of water in Lake County, Colo., in the drainage basin of the Arkansas River, and situated on Lake Creek, one of its tributaries. The site was one of the first segregated by the U. S. Geological Survey, and has been very fully reported on by this survey. There are several reservoir sites on the different headwater streams of the Arkansas in this locality that have been surveyed, but this is declared to be the best and most economical one of them all.

The Twin Lakes have a drainage area of 102 sq. miles, in the highest parts of the Sawatch range of mountains. They are 15 miles south of Leadville and 2½ miles from the nearest railroad station. The elevation is 9,200 ft. above sea-level. Of the two lakes the lower is about three times as large as the upper one. The fall from the upper one through the narrow outlet to the lower one is about 6 ft.

These lakes were formed by a glacier which in its course through Lake Creek Canon brought down a great amount of debris, building for the lower four miles high lateral moraines for the sides of the lakes; also two terminal moraines were made across the valley, forming two natural dams, one at the lower end of each lake. The greatest depth of the lakes is about 80 ft. It would be enormously expensive to ever drain the lakes to even one-half of their present depth, and most of the effective capacity of the reservoir must be obtained through raising the surface by damming the outlet.

The government made careful surveys for a reservoir that would raise the level of the water from 35 to 40 ft., cover an area of 3,475 acres and hold 103,500 acre-ft. of water that could be drained off through the natural outlet. The estimates of the cost of this reservoir called for an earth dam 3,650 ft. long, with a maximum height of 73 ft., costing $91,000. The outlet conduits would be through this embankment, and on account of the enormously heavy masonry work required for safety they would cost $54,000 additional. The building of the reservoir to this great size contemplated, however, the diversion of water into it from the Arkansas River, and the abandonment of several other sites on the tributaries of the river further up. After several projects on the part of private parties to utilize the reservoir site, one has lately been formulated that should soon make the great natural advantages here offered available.

The Twin Lakes Reservoir Co., of Pueblo, have secured the site (their filing for right of way having been approved by the government in May, 1897), and in May of this year awarded a contract for the necessary outlet work. This company will store water to be turned into the river during the irrigation season and then diverted into the Bob Creek Canal, a large canal tapping the Arkansas, about 20 miles east of Pueblo, and irrigating a large area of land along the Missouri Pacific Railway. This canal has heretofore suffered greatly for a supply during the low-water season, and the owners are nearly the same as those in the reservoir company.

The reservoir level will be raised 9½ ft. higher by a dam across the Lake Creek outlet. The dam will be of earth, 15 ft. high at the creek bed, about 400 ft. long over all, and 20 ft. wide, and will be comparatively inexpensive.

The outlet canal will drain the lake to 16 ft. below the present level, making 25½ ft. of effective depth. A marked peculiarity of the attempts to secure this reservoir site have been the filing on it by different parties claiming the water at different levels, thus cutting it into horizontal slices. The filing approved by the government gives this company 20,645 acre-ft. in the 9½-ft. slice; the 16-ft. slice below this and containing 28,102 acre-ft. has a rival claimant, while a survey has been made by the company with the view of increasing the depth by 8½ ft. above the 9½-ft. slice, which would give a surface area of 2,603 acres and increase the effective capacity by over 20,000 acre-ft., or to 69,000 in all.

The outlet canal, now being constructed, is the main source of expense in the plans of the company, as it will not take the water out through the dam, as was contemplated in the estimates by the Geological Survey.

The canal is located some distance north of the dam. It is 3,000 ft. long, with a maximum cut of 35 ft. It contains about 180,000 cu. yds. of material, mostly gravel. It has a grade of 2 ft. per mile. About 600 ft. from the head of the canal are placed the outlet gates, which require very heavy and substantial construction. The masonry sides of the structure here are 75 ft. long, 12 ft. wide at the bottom, and 2½ ft. at the top, and are 38 ft. high. They rest on a foundation of concrete 1 ft. thick. At the lower end each is continued out by about 30 ft. of pile structure with a 3-in. plank wall. Half-way between the masonry sides or abutments is a masonry pier, 4 ft. wide by 46 ft. long. The two spans formed are 18 ft. 10 ins. long, and each has six gates, 2½ ft. in width in the clear by 5 ft. high. The gates are made of two plates of ½-in. iron riveted together. Above these are flash boards ½-in. thick, slotted on the edges for fitting on to their guides. As these rest on top of the gates, the whole series in one bay is lifted by the worm and screw gearing in raising the gate. The gates proper are placed at 25 ft. below the upper end of the masonry channel, and the floor of this channel is made of a 5-ft. layer of concrete with railway rails imbedded. The space just below the gates is boxed in with a series of wooden dead-air chambers, in four rows along the gates. These are to prevent the freezing in of the gates during winter, and, though an innovation, they are badly needed at so high an altitude.

The contractor for the canal and headgate is the Shutt Improvement Co., of Pueblo, where also are located the offices of the company. The engineering work has been done by Mr. Fred. Warren, with Mr. Gordon Land as consulting engineer.

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In another column will be found a brief paper by Prof. W. H. Burr, of Columbia University, on the subject of the strength of cast-iron columns, which confirms the views heretofore expressed by this journal as to the utter unreliability of cast-iron columns, especially when proportioned by the old formulae. There is great need that the attention of architects and engineers be called to the treacherous nature of cast-iron columns and to the worthlessness of the old formulae based on Hodgkinson's experiments. Cast-iron columns are still being used in high buildings, and opinions in their favor are still being published by those who should know better. In the "Journal of the Western Society of Engineers" for April, there is a paper by Mr. Francis C. Moore, of New York city, copied from the "Brickbuilder" for March, in which he says:

> In my opinion, cast-iron columns are superior to steel, and more reliable. It is not generally known that American cast iron is vastly superior to English cast iron, and will stand a greater strain without breaking. Cast iron, moreover, will not expand under heat to the same extent as wrought iron and steel, which is another fact, in its favor.

Ignoring the results of the tests by the Building Department of New York city, of brackets cast on cast-iron columns, reported in our issue of Jan. 20, 1898, which showed that such brackets are alarmingly irregular and exceedingly low in strength, he says:

> Columns should be without rivets, and the beam-bearing bracket shelf on cast-iron columns should be cast in one piece with the column.

It is rather surprising to find Mr. Moore's views republished without comment in the "Journal of the Western Society of Engineers." We trust that in the next issue of the "Journal" it will publish Prof. Burr's article as the proper antidote to them.

The statement made by Mr. Moore, that "American cast-iron is vastly superior to English cast-iron," which, he says, "is not generally known," is one which has been published repeatedly during the past forty years, so that, whether true or not, it should be well known on account of its constant reiteration. It probably originated with the tests by Major Wade, U. S. A., reported in 1856, of the strength of cast-irons specially selected for the manufacture of cast-iron guns. Some of the cold blast charcoal irons made from Salisbury, Conn., ores showed a strength much greater than that of any irons which had been tested in England, but it was not then, nor has it ever been since, fair to attribute the good qualities of these special irons to all American cast-iron of every grade, nor to compare them with ordinary English irons. The cast-iron used in making columns in this country is ordinary hot blast iron, and we do not believe it is any better than the cast-iron used for the same purpose in England.

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The building of the large new basic open-hearth steel works of 1,000 tons daily capacity, at Ensley, Ala., the contract for which has been given, as noted in our news columns, is likely to be an event of great importance to the American iron and steel industry. The manufacture of steel in the Birmingham district has been projected for many years, and about two years ago a small steel plant was erected at the Birmingham rolling mill, which demonstrated that basic steel of good quality could be made form Southern ores. Until now, however, the time has scarcely been ripe for the erection of a large plant. During the last two years many things have happened which have made its prospects of success more encouraging, and have even made it almost a necessity to the Southern iron producers. The great lowering of cost of production of pig iron in the North, due chiefly to the cheapening of transportation of the Lake Superior ores, and to the improvement of blast furnace practice, has tended to limit the market for Southern pig irons, or at least to keep their market price permanently so low as to endanger the profits of the furnaces. The possibility of running basic open-hearth furnaces with melted pig metal taken direct from the blast furnaces, has recently been proved at Homestead, and this will cheapen the cost of open-hearth steel and make it practically the same as the cost of Bessemer. The opening of foreign markets for American steel within the last two years makes an outlet for Southern steel, which otherwise would have had to find its chief market in the North, at a great disadvantage on account of freight, as compared with Northern works. The low ocean freights on iron and steel from Southern to European ports, in connection with cotton freights, are an especial advantage to a Southern steel works. These features of the trade situation are all favorable to the prospects of the new Alabama steel plant.

◆

Prof. Benjamin's paper, "Experiments on Cast-Iron Cylinders," which we give, somewhat condensed, elsewhere in this issue, is a valuable contribution to our knowledge of the subject of the bursting strength of such cylinders. It furnishes new confirmation of the law that "it is the unexpected which happens" when we are dealing with cast iron. The unexpected result in this case is that if cast iron, which in a test bar shows a tensile strength of 24,000 lbs. per sq. in., be cast in the form of cylinders, which are bored out to diameters of 6 to 12½ ins., with thicknesses from 0.40 to 0.65 ins., they will burst under internal pressures which correspond to tensile stresses of from 3,740 to 11,800 lbs. per sq. in., and that only three out of eight cylinders will break in the way they would be expected to break; that is, by longitudinal splitting. While Prof. Benjamin's experiments are of value in calling attention to this peculiarity of cast-iron cylinders, they do not seem to form a sufficient basis for a formula for dimensioning the cylinders of steam engines. The cylinders he tested had a maximum diameter of 12.56 ins., and a maximum thickness of 0.65-in. It is scarcely safe to predict from the behavior of these cylinders what would be the probable strength of larger cylinders.

We fail to see a good reason for constructing the formula (4) in the assumption that there is a "bending movement as at C some weak point," and for the derivation of the average value of C in that formula, 0.6, from a range of 0.3 to 0.10 obtained from an examination of several engine cylinders of standard manufacturers. If the formula itself is derived from a logical basis, it would seem that the constant C should be determined from actual bursting tests of several engine cylinders (not mere examinations), and such tests it does not appear that Prof. Benjamin has made.

Let us apply Prof. Benjamin's formula (6) to the case of three steam engine cylinders, 10, 30 and 50 ins. diameter, for a pressure of 100 lbs. per sq. in.

The formula is:

$$t = \frac{p\,d}{8,000} + \frac{d}{200}\sqrt{p + \frac{p^2}{1,600}}.$$

For the three cylinders the term $\frac{p\,d}{8,000}$ is respectively:

0.125, 0.375, 0.625 ins.

and the term, $\frac{d}{200}\sqrt{p + \frac{p^2}{1,600}}$, 0.515, 1.03 2.575 ins.

adding, we have,

t = 0.64 1.405 3.20 ins.

Prof. Barr's formula, from average practice, $t = 0.05\,d + 0.3$ in., gives:

t = 0.80 1.30 2.80.

In Kent's "Mechanical Engineers' Pocket Book," p. 794, the thicknesses of these three cylinders, calculated from the average figures given by eleven different published formulas, are:

t = 0.76 1.48 2.26.

Kent's approximate formula, made to fit these averages, is $t = 0.0004\,d\,p + 0.3$ in., and the thicknesses calculated from this formula are:

t = 0.70 1.50 2.30.

Prof. Barr's formula agrees exactly with Kent's if, in the latter, p is taken at 125 lbs. per sq. in.

The eleven formulae above mentioned give the following ranges of thicknesses:

Minimum...	0.33	0.99	1.56.
Maximum...	1.13	2.00	3.00.

Prof. Benjamin's formula (6) gives for the 50-in. cylinder a thickness of 3.20 ins., which is greater than that given by any one of the eleven formulae quoted by Kent, while his figure for the 10-in. cylinder is much smaller than is given either by Prof. Barr's formula or by Kent's. For these reasons it does not seem advisable that Prof. Benjamin's formula (6) should be adopted as a working formula for dimensioning engine cylinders.

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Prof. Benjamin's paper raises some interesting questions relating to an entirely different industry, the manufacture of cast-iron pipe. It will be noticed that in several of the cylinders tested, leakage occurred through minute blow holes, sufficient to interrupt the test until the holes were stopped by peening or filling with soft metal. Now, if cylinders like these have such blow holes, do not similar blow holes exist in cast-iron water pipe? These cylinders were cast, it is fair to presume, with far more care than is exercised in any pipe foundry. The thickness of the metal was as great as is found in cast-iron pipe of 10 to 30 ins. diameter. If these cylinders had blow holes we know of no reason to suppose that cast-iron pipes do not have similar blow holes. On the other hand, we know that very few lengths of cast-iron pipe have to be rejected for leaks under the hydraulic test, and leaks in water mains after they are placed in the ground, which are found to be due to holes through the pipe itself, are quite infrequent. It is interesting to inquire the reason for this, and the most probable reasons appear to us as follows: In the first place, the cylinder castings have the skin of the metal removed on the interior, thus laying bare any spongy places in the interior of the metal. It is quite likely that the skin of the metal in a cast-iron pipe is more solid than its interior. In the second place, all cast-iron pipe is dipped in a bath of protecting coating, which not only covers the surface of the metal on both sides, but runs into and fills any small cavities and blow holes that may exist. Further, the coating in any such blow holes is in a large measure protected from the influences which tend to destroy or remove the coating on the surface of the pipe, and will probably continue to do its duty in keeping the pipe tight even when much of the interior coating is worn off. Probably very few water-works engineers have ever reflected that water pipe is dipped in a protective coating to make it tight under pressure, as well as to preserve it from rust; but there seems good reason to believe that this is the case.

THE WORK OF THE RAILWAY MECHANICAL CONVENTIONS OF 1898.

In reviewing the work of the Master Car Builders' and Master Mechanics' Associations, in their annual conventions just held at Saratoga, the item which stands out most prominently, perhaps, is the formal action taken by the Master Mechanics' to bring about a consolidation of the two organizations. Barely ten years ago, the proposition to hold the two conventions at the same place, one following the other after an interval of three or four days, aroused considerable opposition among some of the members of both associations. It is quite possible that even this measure of co-operation between the two associations might not have been attained, had it not been for the influence of the supply men, who desired to avoid the expense and trouble of moving their exhibits and hospitalities to two different places; and we hasten to set down at least this item to the credit of that remarkable organization, the Supply Men's Association.

Whatever the influence that effected it, the plan above noted was adopted, and its operation, together with the growing number of railway officers who are members of both associations, has greatly reduced the petty jealousy and rivalry between the two associations that once was evident.

Against such a radical move as the consolidation of the two associations, however, there is no doubt that strong protests will be heard; and the obstacles to be overcome are such that an effective union of the two associations, although it is, we believe, inevitable, is not to be looked for immediately.

As will be seen from a perusal of the convention proceedings, published in this and the last issue of Engineering News, the initiative toward consolidation was taken by the Master Mechanics' Association; the Master Car Builders' Association being entirely silent in the matter. When this fact is considered in connection with the different constitutions of the two organizations, the outlook for early consolidation seems hardly so promising as many of the Master Mechanics seemed to believe.

As most of our readers are aware, the Master Car Builders' Association is not merely a voluntary association of railway officers, like the Master Mechanics', the Roadmasters,' the Telegraph Superintendents' and a dozen similar organizations of railway officers. The M. C. B. Association is, first, an association of railway companies, and, second, a voluntary organization like the others named. It is unquestionably the fact that the radical change which was made in the Master Car Builders' Association by which it became an official organization has given it the prestige and position which it holds at the present day. A considerable number of very able men who would naturally have gravitated to the Master Mechanics' Association by reason of the greater engineering interest attaching to its work, have instead devoted their energies to the M. C. B. Association because of the fact that the actions taken by that body might mean thousands of dollars direct gain or loss to the companies which they served.

Manifestly, if a consolidation of the Master Car Builders' and Master Mechanics' Societies is to be brought about, it will be the Car Builders' which will absorb the other rather than the reverse. In other words, whatever becomes of the two societies as social or technical clubs, the organization of the railway companies for the maintenance of freight car interchange and for the adoption of standards for freight car construction, will continue as before, if not under the name of the Master Car Builders' Association, then under some other name.

Turning now to the reasons why the consolidation of the two associations is urged, it may be said at once that the principal one is the growing practice of placing both car and locomotive construction in one department under a Superintendent of Motive Power and Rolling Stock.

Formerly when one association was composed of master car builders strictly, and the other of master mechanics, there was more reason for separate organization, but of late years the character of the membership has changed very much from these original conditions. Now the active working members of both associations are the superintendents of motive power and the mechanical engineers of railways, who are equally interested in both the car and the locomotive departments, and who control the management of both. The idea that these men should have one meeting one week to consider matters relating to car construction, and after a two or three days' interval, another meeting the next week to discuss questions of locomotive design and construction, hardly coincides with the ideas of a hustling railway officer.

Further, as we noted a year ago, in commenting upon the waste of time and money at the conventions of 1897, General Managers and other superior officers are beginning to object seriously to their heads of car and locomotive departments consuming a round two weeks in attending conventions, of which only from 30 to 36 hours are devoted to actual business. This feeling of opposition, it may be noted here, is not lessened by the reports which they hear each year of the expenditure of many thousand dollars by the visiting supply men in lavish entertainments which, however enjoyable, do not in all respects tend to improve the character of the work done in the conventions.

Such are the forces which are tending to bring the two associations together, and the obstacles which oppose their union. What the outcome will be we shall not now attempt to prophesy.

Turning now to other features of the convention work at Saratoga, attention may be directed first to the important series of tests of triple valves which the Master Car Builders' standing committee on triple valve tests will carry out. Perhaps no single task which this association will undertake during the coming year, except possibly it be the work of the committee appointed to draw up a schedule of tests and specifications for M. C. B. couplers, is of so much importance to the railway companies.

When in 1895, after more or less continuous study since 1886, a code of tests for air brake triple valves was recommended, it was pointed out that new devices were coming into the market about which full knowledge was absolutely necessary to the railways, and as each railway could not itself make the elaborate tests requisite to obtain this knowledge, there should be a standing committee appointed whose duty it should be to test all triple valves submitted to it by the railways represented in the association, and to return reports as to their efficiency. Such a committee was appointed, as we noted at the time, but, although two years have passed and new devices have come out and been put into service, no tests have been made and no adequate knowledge is had by the railways as to whether they comply with the accepted standards or not.

One thing which was proved most conclusively by the long work of the Master Car Builders' committee on air brake tests was that a triple valve which would not interchange perfectly with the apparatus already in use, was not a proper valve to adopt in equipping trains. In the rush to supply cars with air brakes before 1900, in compliance with the Federal safety appliance law, every railway is confronted with the danger that valves may be used merely because they are slightly cheaper than the standard. In instructing the committee to procure and test and report fully upon the efficiency of all triple valves now in the market, the association took a course which will commend itself to everyone who appreciates the great importance to public safety of maintaining a high standard railway air brake service.

Hardly less important was the action taken to have a rigid specification for M. C. B. couplers drawn up. The breaking in two of trains is a prolific source of trouble to-day, and it seems pretty clear that in many instances at least these accidents are due to couplers defective in design and material. If a specification does nothing more than to ameliorate somewhat this trouble it will pay many times for the work of preparing it. There is, however, more than this to the matter. Every railway car official knows that there are to-day in use couplers made of such poor material and so poorly designed and constructed that they are a constant menace. To weed these out of the service will be a work of the utmost value, and this a rigid specification and schedule of tests will do if railways will only live up to their requirements.

Another committee duty which means a great deal in money expenditure to railway companies is that of investigating the justice of allowing a differential to railways west of the 105th meridian (Omaha, Neb.), in charging for repairs to foreign cars. As the rules of interchange now stand, the same schedule of prices must be charged by all railways, irrespective of their geographical location, when billing the owner for repairs made on his cars by foreign lines. On account of the higher cost of labor and materials in the far West, however, it really costs much more for the railways of this section to do this work than the established prices allow them. According to figures presented by the Western members at the convention, this excess in cost averages about 30 per cent. for labor and from 10 to 15 per cent. for materials. On the other hand, the schedule prices allow Eastern roads a fair compensation for their repair work, and this difference the Western roads claim should be equalized by permitting them to charge a higher price, say 15 per cent. more, for all repairs done on foreign cars west of the 165th meridian.

So far as the Western members made themselves heard at the convention they rested their argument solely upon the matter of higher cost of work. This the Eastern members, however, claimed was but one factor in the problem. Another and very important factor they argued was the far greater mileage of Eastern cars upon Western roads than of Western cars upon Eastern roads. As the mileage rate of six mills per mile is claimed to be too small to pay the owners a reasonable rental for their cars, the Western companies were getting the benefit for every mile more that foreign cars ran on their roads than their cars ran on foreign roads. In the aggregate this compensated the Western roads for whatever more their car repairs cost them.

We have merely attempted here to state the leading arguments on each side of this question. It is, however, evident that there are several other factors which need to be considered carefully in order to arrive at a just decision, and that a satisfactory determination of the value of each will be a task of no small magnitude. The committee which is appointed to handle the subject will, therefore, have to consist of men of pretty large caliber, and also of men who are capable and willing to do a large amount of work, if its report in 1899 is to settle the question on a basis equitable to both parties. The matter means much to the railways concerned; and if the threats of some of the Western roads to withdraw their membership are seriously made, it also means too much to the Master Car Builders' Association to be slurred over or incompetently handled.

Passing to the special committee reports and topical subjects presented and discussed at this convention, there are several things which merit brief comment. At least one of the subjects reported upon was over the heads of the bulk of the members, and some comment was aroused as to the wisdom of having such subjects on the programme for consideration. This is a problem which will, we think, find its own solution as time goes on unless all signs fail. Every year more men, of thorough technical education, are entering the mechanical departments of our railways, and these men will, or should be, able to handle these questions of higher technical knowledge adequately whenever they come up. Indeed, there are many members now who are competent to do this, as the quality of the report itself was sufficient to show. Instead of the wisdom of considering such subjects being in doubt, it is a most gratifying evidence of progress that they are presented for consideration and competently handled.

Another feature of especial interest was the departure of the Master Car Builders' Association in two instances from the time-honored "committee report," and the substitution therefor of an individual paper by a member. We commented last year upon the promise of such a policy, and it was especially gratifying to find that this promise was so well fulfilled. In their scope, arrangement and careful consideration the papers on "Air Brake Hose" and "Thermal Tests for Car Wheels" were excellent examples of technical work, and all doubt may, we think, now be laid aside as to the wisdom of the innovation.

Another report which is deserving of particular notice, especially for the side light which it threw upon methods of railway machine shop management was that of the committee upon the "Advantages of Improved Tools for Railway Shops." To one who is at all familiar with the economy obtained by the use of special tools, and with the live, hustling methods of manufacturing machine shops, the backwardness of railway shops in adopting them has always seemed almost inexcusable. There are many obvious reasons, of course, why a railway shop cannot have that extreme division and specialization of labor and tools which characterizes certain manufacturing processes, but it can accomplish a great deal more in this direction than is usually done.

In conclusion, some mention may be made of the exhibit of car and locomotive fittings and appliances made by the leading manufacturers of railway supplies. The magnitude of these exhibits has been increasing from year to year until now they include not only such easily transported things as valves, gages, couplers, fittings, etc., but full size trucks, bolsters, and even complete cars and locomotives. A striking feature of these exhibits at the present convention was the large showing of steel trucks and bolsters designed for high capacity steel cars such as are now coming into use; cast-steel wheel centers, driving boxes and cross heads, and pneumatic hammers, drills, shippers, calkers and boring machines. These are all features which are comparatively new, and were, therefore, of timely interest; and, considering their great size and weight, and the cost and trouble of transporting and installing them, the manufacturers deserve the thanks of the visiting railway men for placing them where they could be so readily examined and compared.

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LETTERS TO THE EDITOR.

Vandyke Solar Paper for Blue Print Negatives.

Sir: Now that Mr. Isaacs has broached the subject of making copies of tracings by means of an albumen paper tedious to manipulate and limited in its result of blue lines on a white background, it may be in order to call attention to the Vandyke Solar paper for the purpose indicated by Mr. Isaacs.

The manipulation of this paper is almost identical with that of blue print paper, except that greater permanence is secured by means of a bath or application by sponge of the Vandyke Salt solution after printing and washing in water. The paper and salt can be had of various stock dealers who issue instructions with every ten-yard roll. Office boys learn the process during one trial. The paper cannot be overexposed so readily as blue print paper, and the lines of the positive print are clearly cut whatever the exposure.

Its present cost, although not much above blue-process paper, prevents its lavish use for making prints; its chief utility is in making dark tan negatives from which blue-process positives are obtained. A dozen negatives can be made from one tracing in quick succession, and all the negatives can be used at the same time in making a dozen of the desired prints. Since the Solar paper can be had in the same size as blue-process paper, the work possible with the latter can be executed on the former. By its use maps, plans and reports can be illustrated by photo negatives on the same sheet that contains the drawing.

Yours truly, John I. Riegel.

Auburn, N. Y., June 24, 1898.

(A correspondent in our issue of June 23 has already called attention to the merits of the "Vandyke" process. As. Mr. Riegel's letter gives some additional particulars as to the applications of the process, however, we give space to it also.—Ed.)

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Tests of Cast-Iron Columns.

Sir: Referring to the report of Mr. Ewing (Eng. News, Jan. 13) on tests on cast-iron columns, it seems to me that the quality of the cast iron in the columns tested should have been more completely ascertained, because we cannot know to what the lack of strength is due—that is, whether it comes from faults in the foundry or from the use of a poor grade of metal. Mr. Tetmajer always assumes a cast iron of about 60 tons per sq. in., while in a recent test of a full sized cast-iron column in Leeds, England, it was ascertained that the cast iron in question had only 30.4 tons per sq. in. breaking strength in a small test piece. [We understand these figures to be for compressive strength.—Ed.]

Your criticism of the New York Building laws everybody will endorse, but it is given in a form that may be misunderstood. Not the formula, but the factor of safety of 5 is the thing which we must object to, while the formula itself, $\dfrac{80{,}000}{1+\dfrac{1}{400}\dfrac{l^2}{d^2}}$, seems to be endorsed by the tests. Those columns which show a fair quality come up to this standard. If, on the other hand, columns of a bad make do not do this, it is rather natural that the factor of safety should be so selected that even in the worst case of hidden flaws, etc., a sufficient remainder of safety shall be shown. That is the reason of there being a safety factor. For instance, taking a factor of safety of 10 with the same formula, there would have remained always 5 times the allowable load.

The tests of Prof. Tetmajer points to exactly the same formula for breaking load as this one given by Haswell. In comparing both we must not be confused by the different analytical form of Tetmajer's, which is as complicated as possible, but it could be given exactly enough by the formula $\dfrac{50 \text{ tons}}{1+\dfrac{1}{380}\dfrac{l^2}{d^2}}$ if we change the form, reduce to flat ends, and translate from metric into English measures. Comparing both formulas, the above, which conforms to the tests of Prof. Tetmajer, and the one from Haswell's pocketbook, you will see that there is no difference except in the numerator, or, in other words, in the quality of the cast iron under consideration—the law is the same in both. Haswell's formula is preferable, in that it can more readily be adapted to cast iron of various qualities. On the other hand. your plea for a greater safety is entirely just. It may not depend on a formula, but on the quality of the cast iron in local use, which figure may be used, and it is rather shorter to leave the "factor of safety" aside and name directly the allowable stress. Hoping to hear what the average breaking strength of cast iron in New York may be and if it was ascertained in the tests made by Mr. Ewing,

I am, yours very truly,

Fr. von Emperger.

Vienna, IV. Technische Hochschule, June 9, 1898.

(We regret that we have no figures at hand which will enable us to give the "average breaking strength of cast iron at New York." We have no doubt that it will be something in the neighborhood of the average breaking strength of cast iron made throughout the world, for the pig iron sold in the New York market is made in locations over 1,000 miles apart, and is of every conceivable grade and quality. We have no report of compressive tests of small specimens having been made in connection with Mr. Ewing's tests.—Ed.)

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The Effect of Temperature on the Flow of Water Through Soils.

Sir: Your recent article on the effect of temperature on the seepage of water has caused me to look over some of the data collected a few years ago. When led to the conclusion that the temperature had a material influence on the flow through soils, little could be found which threw light on the subject, and the values for viscocity given by the different writers were conflicting and seemed irreconcilable. It is only on freshly reviewing the data that some of the discrepancies are explained to my own satisfaction. As some available statement would have saved me personally considerable time, perhaps the following notes may be useful to others, as they would have been to me.

It may be stated that the questions relating to seepage through soils often arise in litigation, especially in the irrigated sections, and are becoming increasingly frequent. There have been numerous cases in Colorado, some of considerable interest from the novelty of the questions involved, and correspondents have informed me of others, as at Los Angeles; in the San Joaquin valley; in Kansas, and in Michigan, where such questions have been in dispute, and where I am informed that Bulletin 33 of the Colorado Agricultural Experiment Station proved of some help in coming to a conclusion regarding the questions at issue.

One immediate result of your note and the renewed attention called to the subject, is that I shall bring out at the first opportunity an apparatus prepared two or three years since to experiment on the flow through soils, but which, because of the inability to obtain particles of uniform size, was left without experimental result. In this case I had arranged to test the flow through soils with different pressures.

The equation representing the velocity of flow through minute capillary tubes is of the form

$$v = \frac{k\,d^2\,h}{l}, \tag{1}$$

where k is a coefficient depending on the coefficient of viscosity, and therefore not constant; d is the diameter of the tube; h the head, and l the length. The formula has been established by many experimenters—generally in a form giving the volume instead of the velocity—the principal one of whom seems to have been Poiseuille.

It is noticeable that the velocity varies directly as the head, and not as the square root of the head, as is the case in larger tubes and according to Torricelli's principle. Darcy showed that the same relation held true in the case of layers of soil of moderate thickness; or, in other words, that the passage of water through soils followed the laws of flow through capillary tubes.

The coefficient k varies inversely as the coefficient of viscosity, or in absolute measures

$$k = \frac{\pi\,\rho\,g}{3\,2\,\eta}, \tag{2}$$

where $\pi = 3.1416$,

ρ = density of the liquid or 1 in the case of water in the c. g. s. system.

g = the acceleration of gravitation = 981 cm. per sec.

η = the coefficient of viscosity.

This, as given in English books, is 981 (the value of g) times the value as given by French writers. It is a force per unit area and its physical dimensions are $\frac{M}{LT}$.

In the case of water, as with other liquids within the range of ordinary temperature, the density is practically constant; g likewise may be taken as constant, so that k varies inversely as the coefficient of viscosity, or as the viscosity decreases the coefficient k increases.

Expressions for the coefficient of viscosity, all showing a dependence on temperature, were given in Engineering News for May 12.

Poiseuille, who seems to have been one of the most extensive experimenters, gave the following expression (the numerator having been multiplied by the value of g):

$$\frac{0.017831}{1 + 0.0336793\,t + 0.0002203936\,t^2}. \tag{3}$$

Hence k, which varies inversely as the coefficient of viscosity, varies directly as the denominator of the above expression.

Letting k represent the value of k at the temperature of melting ice, the value of any other temperature in centigrade degrees would be

$$k = K\,(1 + 0.033679\,t + 0.000221\,t^2), \tag{4}$$

and in Fahrenheit degrees, as given in Bulletin 33, p. 46, Colorado Agricultural Experiment Station,

$$k = K\,[1 + 0.0188\,(t - 32^\circ) + 0.000068\,(t - 32^\circ)^2]. \tag{5}$$

Accepting this as the expression for the effect of temperature, the velocity through tubes like the capillary channels in soils would vary according to the temperature, and if the velocity of 32° F. be taken as unity for comparison, the velocity at 10° intervals would be:

Temp., F.	Velocity.	Temp., F.	Velocity.
42°	1.195	92°	2.372
52°	1.408	102°	2.649
62°	1.625	112°	2.908
72°	1.860	132°	3.500
82°	2.109		

Regarding the effect of the varying soil temperature on the flow through the soils, inasmuch as the variation in temperature rapidly decreases with increased depth, the effect is correspondingly less. The observations of the past ten years at the Colorado Agricultural Experiment Station show that the average temperature at the different depths is nearly if not quite the same, amounting to between 49° and 50° F. (the average air temperature being slightly less than 47° F.), and that the annual range as determined from semi-daily observations is 71° F. at a depth of 3 ins.; 60° at 6 ins.; 48° at 12 ins.; 37° at 24 ins.; 32° at 36 ins., and 22° F. at 6 ft. This range would indicate a variation of over 15% above and below the mean for the depth of 6 ft., or at the warmest portion of the year fully a third more than at the coldest. In the case of the soil at the depth of 2 ft., the variation must amount to nearly 60%, and at 3 ft. to about 45%.

It may be well to point out that formulas (1) and (2) above indicate fruitful lines for obtaining the formulas for the flow of water through soils. In any particular soil the difficulty would seem to be in obtaining the diameter of the equivalent capillary tubes. But in any particular soil of fairly uniform character $k\,d^2$ would be nearly constant, and the product of these two factors could be determined by direct experiment, forming a constant peculiar to each soil, and nearly as useful as if k and d could be separately determined. Allowance for the effect of temperature could be made by (4) or (5) or some of the equivalent expressions.

The determination and tabulation of such values for different soils would be of considerable use. I gave such a table, confessedly approximate, with values for this constant, in Bulletin 33 of the Colorado Agricultural Experiment Station, on seepage waters, referred to by you in the article in your issue of May 12. The data at hand was too meager to insure accuracy in the values given, but with additional data a similar table might be of considerable use.

In examining the subject I have obtained various references bearing on the effect of temperature on flow through soils. Distance from collections of books has prevented personal use of many of the original documents mentioned, but the references may be useful to others who have occasion to form an independent judgment. There are any number of determinations of viscosity.

Poiseuille, "Récherches Experimentales sur le Mouvement des Liquids dans les Tubes de très petite Diammetre," Memoires des Savants Etrangers, t. XI., p. 433 (1846).

O. E. Meyer, Crelle Journal, t. 59; Poggendorff Annalen, t. 113, pp. 55, 93, 183.

Graham, "On the Diffusion of Liquids," Philosophical Transactions, 1850, pp. 1, 805; 1851, p. 63.

Tate, "Experimental Researches on the Laws of Absorption of Liquids by Porous Substances," Philos. Mag., 20:364, 500 (1860). 21:57, 115 (1861). 23:126, 283 (1862).

Darcy, "Les Eaux Publiques de la Ville de Dijon."

Dupuit, "Traité de la Conduite et de la Distribution des Eaux."

Jamin et Bouty, Physique, vol. 1.

Daniell's "Principles of Physics."

Durand-Claye, "Hydraulique Agricole," 1:276-8.

Nazzini, "Idraulica Pratica," 1:606-9.

L. G. Carpenter.

Agricultural College, Fort Collins, Colo., May 24, 1898.

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Across Wyoming by the Union Pacific.

Sir: The country along the line of the Union Pacific in Wyoming is usually considered about as dreary as any on the Western plains, unless it be the Great American Desert. Nevertheless there are not a few things to interest the engineer who journeys through it. The traveler leaving Salt Lake City for the East enters Wyoming after a ride of two or three hours. At Aspen Station 130 miles from Salt Lake, the second highest summit on the road is reached, at an elevation of 7,395 ft. The grade has been upward all the way from the Salt Lake Valley. Evanston, a thriving place of 3,000, is situated just half way between Omaha and San Francisco, 957 miles to either. Here the railway company has extensive repair shops. Around the point of the mountain to the north, 6½ miles away and reached by a spur, are the extensive coal mines of Almy. The Southern Pacific Ry., as well as the Union Pacific, own mines there, and coal is shipped to towns in Nevada and California besides that used by the railways. A little farming is done around Evanston, but it is the last to be seen for hundreds of miles.

At Rock Springs, 125 miles east of Evanston, the writer stopped for a day to see the great coal mines of the Union Pacific Co. Beyond the immense deposits of excellent coal, nature has done precious little for this vicinity.

Imagine a town of 4,500 people situated in a flat valley surrounded by barren ridges, the only stream (called Bitter Creek) so strongly alkaline as to be unfit for either drinking or irrigation. Not a trace of vegetable life is to be seen anywhere save a few stunted bunches of sagebrush and greasewood. All water has to be either hauled or pumped from a place 16 miles distant. Such is Rock Springs. Notwithstanding its desolated aspect, it is the greatest coal mining town in Wyoming, and furnishes the railroad with an immense amount of business. The Union Pacific has 27 miles of track in its switches and spurs here.

Through the courtesy of Mr. Frank S. Davis, chief engineer of the coal department, I was given the opportunity of seeing the mines and the interesting machinery for handling coal. Many Chinese miners are employed, working side by side with the white miners. Rock Springs will be remembered as the scene of the Chinese massacre of Sept. 2, 1885, which resulted in the government establishing Camp Pilot Butte here for the future protection of the Chinese.

Coal was discovered here at the time the railway was put through, in 1869. The outcroppings were very plain, and the results of the mining operations have fully corroborated all indications. This locality is, as just stated, about the most desolate of any in Wyoming, and only pronounced merit of the coal properties could have led to the development of such elaborate plants and the building of a town containing 4,500 inhabitants.

Four separate beds or veins of coal have been found and worked on here, ranging in thickness from 4½ to 12 ft. The mining is done by the Union Pacific Coal Co., separate in management and accounts, but virtually the same as the railway company.

The oldest and largest of the mines, called No. 1, was opened in 1870, and has steadily increased in area worked over and in extent of equipment. The vein is 11 to 12 ft. thick, with a dip of 6° at the surface but increasing steadily to 17° as far as worked, with a curve like a parabola. The main slope is down 5,760 ft., said to be the longest continuous mine slope in the world. It is 20 ft. wide by 8 ft. high, with timbers for supporting the roof and with two tramway tracks. The slope is continued up on a viaduct to the tipples on a level high enough for screening and assorting. There are two tracks for loads and one for empties on the tipples, and by switches the loaded cars are run to either of the two tipples at the end of the tracks.

There are three screens for each tipple, one of bars spaced 3 ins. for separating lump coal, then a screen of 1¾-in. mesh for egg, and one of 1¼-in. for nut; the rest is slack. These are shaker screens, unusual in the West, but needed here on account of the ease with which the coal breaks in handling. The discharge is directly into the cars on the loading tracks, steam shovels or coal distributors, made by the Ottumwa Iron Works, of Ottumwa, Ia., being used at all the mines. The hoisting apparatus is placed in a building just beyond the tipples and end of the tracks, several hundred feet from the mouth of the slope. The cars weigh from 1,050 to 1,200 lbs., and carry from 3,000 to 3,500 lbs. of coal. They are made up in trains of 14 each, and move at about 15 miles per hour. One loaded train is pulled up while a train of empties is being let down, the friction clutch of the drum for the latter being released and the speed controlled by the band brake..

Near the mouth of No. 1 is also the electric light and power plant, supplying light for the town and power for electric motors in some of the mines. There are 800 to 900 incandescent and 22 arc lights supplied. The electric light machinery is not well proportioned, but as the fuel is very cheap it has never been remodeled.

On one side of the main slope of No. 1 is the man-way, and on the other is the air-course, each separated from it by about 50 ft. of the coal bed at the upper end and by about 100 ft. at the lower end of the slope, where the covering is thicker. Each is 8 ft. by 14 ft. They start about 200 ft. below the mouth of the slope. Connected by a vertical shaft over the upper end of the air-course is the fan. The average amount of air exhausted per minute is 95,000 cu. ft. For supplying compressed air for the machines in No. 1 mine, there are at the shaft house of No. 3 mine (now abandoned) two of the Norwalk Iron Works compressors. The supply pipes lead from these to the bottom of No. 3's 180-ft. shaft and thence through a drift to directly over where needed, from which an 8-in. pipe (sunk by boring the same as for a well-casing) leads down to the workings of No 1. The compressors have each a 24-in. steam cylinder and two air cylinders—the intake cylinder of 26 ins. and the compressor cylinder of 18 ins. The air pressure is 90 lbs.

Of the nine mines opened by the company, all but four are now abandoned on account of the coal giving out. Mines Nos. 7, 8 and 9 have veins 4½ to 7 ft. thick. The lengths of the main entries of these are as follows: No. 7, 1¾ miles; No. 8, 1¼ miles; No. 9, 1½ miles, all being called levels, while No. 1 has the slope of 5,760 ft. There are about 15 miles, all told, of working entries in the mines, and about 25 miles of tramway track. Mine No. 9 has lump, egg, nut and pea screens. No. 7 has no screens, but loads run-of-mine coal, mostly for the locomotives of the road. No. 8 has all the different screens, those for it and No. 9 being shakers. At the old No. 4 mine engine house are four air-compressors, somewhat smaller but similar to those of No. 1 mine, which at present furnish air for work in No. 8. No. 9 mine has a No. 4 Root blower for slack, discharging through a 6-in. pipe to the waste dumps several hundred feet away.

The main entries of No. 7 and No. 9 have each a Jeffrey electric motor for hauling tram cars. These are 500 V.-10 M.-D.M.-60 B. motors, weighing about 10 tons each and working up to about 60 HP. One motor hauls 48 empty cars up a grade that reaches as much as 2½% in places in No. 7. The cars here load only about 2,400 lbs. of coal, and weigh 800 to 900 lbs. The entrances to mines No. 7 and No. 9 are less than 300 ft. apart, and at times the cars from one are unloaded at the assorting tracks of the other, the motor handling but 24 cars in the switching, on account of certain difficulties in it. At No. 8 mine is a General Electric motor, much lighter than the others, and running at only 8 miles per hour, while they run at 10. Each takes its current from a side trolley wire running over the edge of the motor.

The workings of No. 8 mine are reached by a 180-ft. shaft at its engine house, while the levels for No. 7 and No. 9 start directly at the surface. All the main levels are double, the upper for working, the lower (the dip of the vein averaging 5° to 6°) is for air. The pillar left between varies in width according to the thickness of the vein. In working the coal the "long wall" method is not used, on account of the veins being usually too thick, but the coal is taken out in rooms reaching from a side-entry to the one next above, on the top of the vein. They vary, but average 24 ft. in width and 300 to 400 ft. in length, two rows of timber being used. In all the entries and hauling roads about 18 ins. of the top of the vein is left for a roof, as the coal makes a much better and less dangerous roof than the stone above it. The entries are connected at intervals by planes having tramway tracks. The cars on each of these are usually handled by an engine and hoisting drum at the upper end, while mules are used on all the entries but the main ones. The entries are about 8 ft. wide for single and 14 ft. for double tracks. All the connections required between rooms and between entries for the circulation of air are provided.

On all but the thickest veins are now used the Jeffrey air-power coal mining machines. These under-cut the vein at its foot, a cut of 6 ins. high, 3 ft. wide and 6 ft. deep being made in 5 or 6 minutes. When the width of the facing of a room is under-cut, a hole is drilled at each of the two upper corners of the face, black powder is used and the whole face torn down. The Jeffrey "Giant" air-power coal drills are also used.

Each of mine Nos. 1, 7, 8 and 9 has at present a capacity of 1,500 tons per day when crowded. All work is done with day shifts. They are at present turning out from 4,000 to 4,500 tons per day, and working 1,200 to 1,500 men. No. 1 has the greatest extent of workings. The output is greater during the winter.

As stated before, all water has to be pumped in from Green River, 16 miles distant. The citizens marked the completion of the pipe line, on Jan. 9, 1888, by a grand celebration, as since 1869 a water train had been required to haul the water.

From Green River to Rock Springs the rise by the railroad is 183 ft., and in pumping water from the river the rise is 260 ft. At the pumping station are twin duplex Knowles steam pumps (one always in reserve), with 16-in. steam cylinders and 7-in. plungers. Steam is supplied by three tubular boilers, 16 ft. long and 5 ft. diameter. The pump pressure is 175 to 190 lbs. The pipe line is 17 miles long, generally following the railway, and is of special 8-in. cast-iron pipe, varying in weight from 70 lbs. per ft. at the lower end to 45 or 50 at the upper. This pipe occasionally fails, on account of the great strain on it, and the water is then shut off for some hours, while Rock Springs then depends on its reservoir. This reservoir was made by closing up a natural basin in the hills near town with an earth dam and then cementing the sides and bottom. The inlet pipe is at the bottom. It holds 5,000,000 gallons when full to 35 ft. depth, but is not usually filled beyond 10 ft. deep, as it is difficult to get the pressure to elevate the water the additional 25 ft. on account of the draught at the town. The reservoir is about 300 ft. above the pumping station. An average of 200,000 gallons per day is pumped, of which the mines use by far the greater amount, No. 1 mine alone using 2,000,000 gallons per month. The distribution system consists of 8, 6 and 4-in. pipes. There are 52 4-in. hydrants, with double 2½-in. nozzles, for which the city pays $40 per year. The charge to consumers is $2.50 per 1,000 gallons, Crown meters being used. The Green River Water-Works Co. is the name of the owner of the water-works, but they are owned by the Union Pacific Co., as is virtually all the town.

Besides the four mines at Rock Springs the company operates one at Almy (on a spur and 6½ miles from Evanston), one at Carbon and one at Hanna (reached by a branch 20 miles long from Medicine Bow. The third has a maximum capacity of 1,500 tons, the others of 800 or 900 tons each.

The coal mining department is under one management, with headquarters at Hot Springs, and so the machinery is transferred from one point to another, as deemed best. Much of the machinery of the company has become antiquated during the 28 years since the first mine was opened, and some of it cast aside.

The officers of the coal company are as follows: Mr. G. L. Black, Asst. Superintendent; Mr. F. S. Davis, Chief Engineer; Mr. Robt. Muir, Master Mechanic, and Mr. M. Griffiths, Supt. of Mines. Mr. E. L. Emery is Superintendent of the Water-Works. Mr. D. O. Clark is General Superintendent, at Omaha, the others named being at Rock Springs.

Traveling on eastward nearly a hundred miles further the Continental divide is reached at a point 30 miles west of Rawlins. Standing on this spot, which is marked by a sign-board on the north side of the track, it is hard to believe that we are on the center of the grandest range of mountains on the continent. The surface seems but a once level plain, broken occasionally into ugly hollows and knobs. One can scarcely realize that if a spring were to issue from some sage-brush knoll here its waters would divide and eventually mingle with either of the two oceans which wash the opposite sides of the continent. The altitude of the divide is 7,100 ft.

At Laramie, 500 miles from Salt Lake, one sees again the welcome sight of green trees along streets watered by irrigation streams, a restful sight after the many hundred miles of barren desert. Laramie has an interesting history, and has been the scene of more ambitious enterprise than any town of its size in the West. It was founded in 1868, when the railroad went through. Laramie was the first place in America (1869) where a female jury was impaneled. Their first case was that of a Western desperado, and they gave him the full extent of the law.

The Laramie rolling mills were built in 1874 by the Union Pacific Ry. They have been operated most of the time under lease by the Laramie Iron & Steel Co., Mr. Otto Gramm, president and manager. No puddling is done, but scrap iron is furnished by the Union Pacific Ry. Co., brought from all over its system. The yearly output is now about 9,000 tons, mostly angle bars for the railway company. In addition, the mills roll tramway rails of 8 to 20 lbs. weight, and make track bolts and spikes, merchant bar iron and material for the car shops. Most of the machinery in the mills is now of ancient pattern, but still does good survice.

One of the earliest installations of electric light plants in the United States was made at Laramie, somewhere from 1883 to 1885. The old machines are still in use, though the plant has been remodeled. There are four of the Edison "Municipal" dynamos of the 1882 pattern coupled to a shaft driven by an Ide engine at each end.

There is also an arc lighting machine driven by a separate engine. Only about 75 ft. from the light station is a flouring mill, in which was made what is said to have been the first attempt in this country to use electrical power to drive a factory. Current was supplied from the light station to 25-HP. motors for driving the machinery. The mill worked all right, but as grain had to be shipped in from other states to supply it, it did not pay and was soon shut down. Both the electric light and power installations were made by Mr. R. M. Jones, an electrical engineer now located at Salt Lake City.

About 1890 glass works were built at Laramie, the inducement being the excellent sand and soda available near town. But they could not compete with the Eastern works on account of the high wages and also the difficulty of getting skilled labor here, so they were soon closed.

Some 15 years or more ago the railroad company erected extensive chemical works at this point and built a branch line to some soda lakes about 13 miles southwest of the town, all at an expense of about $250,000. The largest of these lakes covers an area of 60 acres, with others not much smaller. In the large lake are crystals a foot thick, forming naturally by evaporation.

It is claimed that together the lakes form the largest deposit of nearly pure sulphate of soda in the world. The beds average 10 ft. in depth. The company which leased the plant endeavored to find a good process for making caustic soda from the deposits, but failed, and this enterprise went the way of the others. About four years ago a concern called the Laramie Standard Cement Plaster Co. built a large plant at the edge of town for the utilization of extensive beds of natural cement plaster, and purchased 1,000 acres in the bed of an old lake adjacent to the works.

This cement plaster is a peculiar material, and there are but three other places in the country where it is worked. These are Quanah, Tex.; Marlow, I. T., and Dillon, Salina county, Kan. The cement material at Laramie is easily worked and is said to make an excellent product; but through unskilled management this project also proved a failure.

The population of Laramie was 7,000 or 8,000 in the '80's, and is now about 3,000 less.

Leaving Laramie for the east the first object of interest to the engineer is the Dale Creek bridge. This structure is about 600 ft. long over all, and is 123 ft. above the bed of the creek. It was first constructed of spliced pine or spruce timbers. About 1875 the American Bridge Co. removed the old structure and replaced 520 ft. of it with an iron viaduct of 13 40-ft. spans. These were deck Pratt trusses resting on towers, made up of columns 10 ft. apart transversely and battering 1 in 8. Bracing in the usual manner divides the towers into sections of 30 ft. and less. The columns are of the old "American column" type, each with a sectional area of 18.6 sq. ins. They set in cast-iron shoes resting on masonry or rock in place. After some years it became apparent that the increasing loads were becoming too heavy for the trusses, though the towers were still of ample strength, so in 1885 the trusses were removed and replaced by plate girders. The iron work was furnished by the Detroit Bridge Co., and the erection was done by the regular bridge force of the railway company. The change from truss to plate girder spans was made without the use of false-work and without interfering with trains. About 3½ miles beyond the Dale Creek bridge is Sherman, the summit of the mountains and the highest point on the line. The elevation is 8,247 ft. Sherman is 33 miles from Cheyenne. On a high point just to the south of the station is the great stone monument erected to the memory of the Ames brothers, for the very prominent part they took in the building of the road.

Just 6.65 miles west of the old depot at Cheyenne was the dividing line between plain and mountain of the Union Pacific Ry., officially declared to be the "base of the Rocky Mountains." Here, going west, the rate of subsidy was changed from $16,000 per mile to $32,000 per mile, and further on it became $48,000 per mile.

Cheyenne is the midway point on the line between Omaha and Ogden, 516 miles to each. It is the capital and chief city of Wyoming. The only stream is Crow Creek, winding around two sides of the town and furnishing its supply of water. Some three or four miles from the lower part of the town filter galleries are built along the creek, composed of large porous tiling of oblong section, laid on the bed of the creek and covered with gravel, through which the water percolates. The water from these filters is carried by a pipe to a masonry reservoir holding about 1,000,000 gallons, situated nearly a hundred feet above the city. There is also an independent supply used for fire purposes or for lawn sprinkling. This consists of a pipe line carrying water direct from the creek to four large open reservoirs about a mile north of the city, holding between 300,000,000 and 400,000,000 gallons. For domestic use water from these is piped down to the lower filter beds, on the creek near the railroad, and filtered there. The water from these filters flows into an adjoining concrete reservoir holding 2,000,000 gallons, from which it is pumped into the city mains.

I visited the state engineer's office while here, and was much interested in its arrangement and methods. Wyoming has taken the most radical and advanced steps of any state for the control and use of its water supplies. The office of state engineer is really the most important one in the state, in so far as the public welfare is concerned. Mr. Edward Mead, M. Am. Soc. C. E., has held the office since the creation of the state, and was the territorial engineer before that. He has drafted nearly all the irrigation laws, and has done very much toward making systematic and comprehensive the administration of the same.

The great Union Pacific shops here, built in 1890-91,[*] have never been worked to anything like their full capacity, and this has lately been the cause of complaint on the part of the citizens. At present only 260 men are employed in the shops, while they have a capacity for working 1,000 men. The large car and wood-working departments have never been used at all, and their expensive equipment of machinery lies idle. Lately, however, the company has been decreasing the force at other points and bringing the work here.

Denver, Colo., May 21, 1898. W. P. H.

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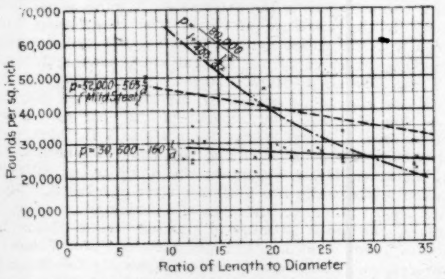
TESTS OF FULL-SIZED CAST-IRON COLUMNS.

The tests of cast-iron columns made last year by the Building Department of New York city, and reported in our issues of Jan. 13 and 20, 1898, and the tests made at the Watertown Arsenal in 1889-90, have been made the subject of a study by Prof. Wm. H. Burr, Professor of Civil Engineering in Columbia University: His results and conclusions are given in a paper published in the "School of Mines Quarterly" for April. We give an abridgment of his paper below, and commend it to the attention of all engineers and architects who may be contemplating the use of cast-iron columns in their designs:



Tests of Full-sized Cast-Iron Columns Compared with Old Formula and with Formula for Steel Columns.

Although cast-iron columns are among the oldest of metallic structural members, it is a little singular that they have been tested to failure only within the last ten years, and in small numbers. This is the more serious for the reason that to the non-technical mind the short brittle fracture of cast iron indicates hardness and strength rather than unreliability and weakness.

The data afforded by the results of Hodgkinson's tests of small model columns, together with the results of tests of short cast-iron blocks, have been the basis of the formulae and tables used in the design of cast-iron columns in nearly all structural practice to the present time. That practice has chiefly represented building construction, for the reason that civil engineers have excluded cast-iron columns from bridge structures for more than twenty years. They have realized that the empirical basis of the formulae in use was dangerously insufficient, and the early experiences with column fractures in railroad bridges constituted a clear and conclusive demonstration of the marked unfitness of cast iron for such purposes. The continued use of cast-iron columns in buildings, however, renders imperative the testing of full-sized members of that class to destruction in order to determine rational and safe working stresses.

It was not until 1888-1889 that a series of the needed tests was begun at the request of Prof. Lanza, in the large Emery machine at the United States Arsenal at Watertown, Mass. Those tests have been followed by others at Phoenixville, Pa., made under the auspices of the Department of Buildings of New York city in 1896 and 1897. Although the entire series, including both the tests at Watertown and Phoenixville, do not cover the variety of sectional forms and range of ratio of length to diameter that could be desired, the results are sufficiently extended to show closely what may be considered the proper ultimate values for hollow, round cast-iron columns of full size.

(Here follows a table of results similar to those given in our issues of Jan. 13 and 20.—Ed. Eng. News.)

As will be observed both in the table and in the plate, the ultimate resistance per square inch determined by the tests are quite variable, even for the same ratio of length over diameter. Indeed, in a number of cases they are quite erratic. In Nos. 1 to 6 (15-in. columns), for which the ratio of length over diameter was 12.7, the ultimate resistances vary from a little over 24,000 lbs. per sq. in. to over 40,000 lbs. per sq. in., with no failure at the latter value. Again, the ultimate resistance per square inch for No. 25 (7½-in. column), which shows a ratio of length over diameter of less than 20, is nearly 47,000 lbs. per sq. in., which is excessively high as compared with other ultimate resistances with the same or less ratio of length over diameter. These erratic results are not surprising in view of the ordinary character of the metal. It should be remembered that the failures of these columns are frequently recorded with such "remarks" as the following: "Foundry dirt or honey-comb between inner and outer surfaces," "bad spots," "cinder pockets and blow holes near middle of column," "flaws and foundry dirt at point of break." In other words, it was no uncommon feature to observe that defects, flaws or blow holes or thin metal had determined the place of failure. There is considerable uncertainty in plotting the results of tests affected by these abnormal conditions, but a more or less satisfactory law for the generality of cases may be determined from a graphical representation of the results, as shown on the plate. On that plate the ultimate resistance in pounds per square inch have been plotted as vertical ordinates, while the ratios of length over diameter are represented by the horizontal abscissas. The full straight line drawn in about a mean position among the results of the tests probably represents as near as any that can be found a reasonable law of variation of ultimate resistance with the ratio of length over diameter. It is evident that within the range of these experiments a straight line will represent the ultimate resistances fully as well as any curve, if not better, although the results for the lengths of 34 times the diameter begin to indicate a little curvature. The formula which represents this straight line, i. e., which gives the ultimate resistance per square inch, is as follows:

$$p = 30{,}500 - 160 \frac{l}{d} \qquad (1)$$

It is to be borne in mind that these columns were round and hollow, and that they were tested with flat ends in all cases. The ordinary formula, based upon Hodgkinson's tests, and frequently used in cast-iron column construction, and practically required by the Building Law of New York city, is as follows:

$$p = \frac{80{,}000}{1 + \frac{1}{400}\frac{l^2}{d^2}} \qquad (2)$$

The curve corresponding to this particular form of Tredgold's formula is also shown on the plate. It will be seen that at the ratio of length over diameter of 10 to 12 (not an uncommon ratio) the ultimate, as given by this formula, is just about double that shown by actual test. In other words, if a safety factor of five were required, as is the case in the New York Building Law, the actual safety factor would be but 2½. At the upper limit of length over diameter, permitted by the Building Law, viz.: 20, the ultimate resistance given by the ordinary formula, Eq. 2, is about 1½ times as great as it should be. In other words, if the safety factor were five by that formula the actual factor $l \div d = 20$ would be but a little over three. The curve represented by Eq. 2 is seen to cross the true curve at a ratio of length over diameter of about 29. A glance at the plate will show how utterly erroneous and dangerous is the use of the usual formula for hollow round cast-iron columns; indeed, that formula is grossly wrong, both as to the law of variation and the values of ultimate resistance.

The broken line of short dashes represents the formula

$$p = 52{,}000 - 563 \frac{l}{a} \qquad (3)$$

determined by actual tests of mild steel angles made by by Mr. James Christie at the Pencoyd Bridge Works, and which are well known among civil engineers. This line or formula shows that the ultimate resistances per square inch of mild steel columns are from 40 to 50% greater than the corresponding quantities for cast iron, the same ratio of length over diameter being taken in each comparison.

When the erratic and unreliable character of cast iron is considered, it is no material exaggeration to state that these tests show that the working resistance per square inch may probably be taken twice as great for mild steel columns as for cast iron; indeed, this may be put as a reasonably accurate statement.

The series of tests of cast-iron columns represented in the plate largely destroys confidence in the cast-iron column design of the past. The results of the tests constitute a revelation of a not very assuring character in reference to cast-iron columns now standing, and which may be loaded approximately up to specification amounts. They further show that, if cast-iron columns are designed with anything like a reasonable and real margin of safety, the amount of metal required dissipates any supposed economy over columns of mild steel. As a matter of fact, these results conclusively confirm what civil engineers have long known, that the use of cast-iron columns cannot be justified on any reasonable ground whatever.

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THE EDISON ELECTRIC ILLUMINATING CO., of New York city, it is reported, will send several of its engineers abroad to study the methods of generation, distribution and sale of current in Europe.

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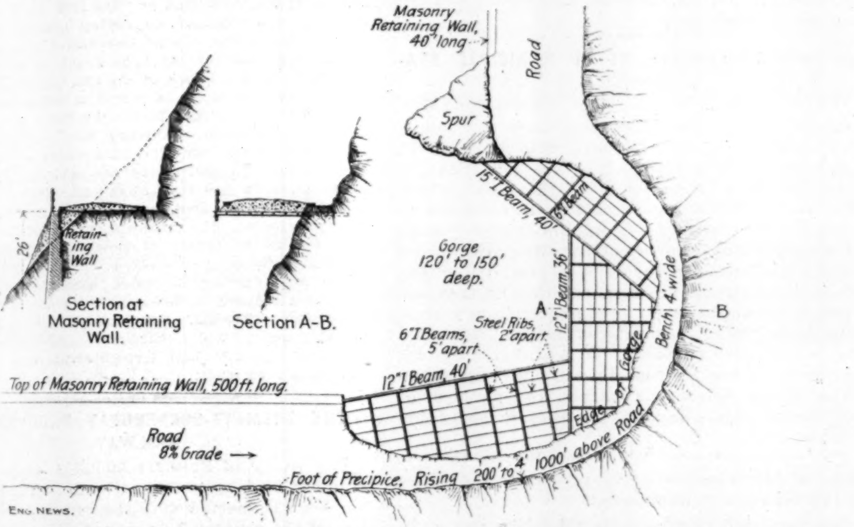
[*] Eng. News, May 9, 1891.

ENGINEERING WORK IN THE HAWAIIAN ISLANDS.

An interesting piece of engineering work recently completed, about six miles from the city of Honolulu, Hawaii, is the construction of the Nuuanu Pali road, up a steep mountain side. Formerly there was a steep and rough road or trail, available for pedestians only, and travelers went by carriage to one end of the road, made their way over it, and then took carriages which were waiting at the other end. In 1889 a new road was located by Mr. W. W. Bruner, the Government Engineer, and work was commenced, but was later abandoned on account of lack of funds. In 1897 new funds were available, and the road was relocated. On May 24, 1897, the contract for its construction was let to Wilson & Whitehouse, engineers and contractors, of Honolulu, at $37,500. The main road is 7,600 ft. long, with a grade of 8%, and there is a branch road of easier construction, 4,300 ft. long, with a grade of 6%. The line is benched out of the steep mountain slopes for the greater part of the distance. The deepest cut is 90 ft. deep, through a ledge of decomposed volcanic rock, and the road crosses one stream by a 5-ft. stone arch culvert. In one place the road is supported by a masonry retaining wall 500 ft. long, with a maximum height of 26 ft., this wall being 24 ins. wide on top, with a face batter of 2 ins. per ft. This wall is of stone, laid in Portland cement mortar, and its location is shown by the accompanying sketch.



SKETCH OF STEEL AND CONCRETE PLATFORM CARRYING A CURVE OF THE NUUANU PALI ROAD, NEAR HONOLULU.

At the lower end of the wall the road makes a sharp curve around the edge of a deep gorge, and is supported by a steel framework overhanging the gorge, as shown by the sketch, which is not drawn to scale. A 15-in. I-beam, 40 ft., long, is let into the rock at each end, and near its middle carries one end of a 12-in. I-beam, 36 ft. long, whose other end is let into the rock. Another 12-in. I-beam, 40 ft. long, extends from the second beam to the retaining wall. Floor beams of 6-in. I-beams, 5 ft. apart, extend from the three large beams to the rock, and between these are steel ribs 2 ft. apart. A false or temporary floor was suspended under the steel frame work, and a solid floor of 8 ins. of concrete put in, enclosing the beams. A bench 4 ft. wide, following the grade line of the road, was cut in the mountain side, which is here a steep precipice, rising 200 to 1,000 ft. above the road, and falling 120 to 150 ft. below it. At the end of the curve a projecting spur was cut away, and then another section of the road was supported by a masonry retaining wall 40 ft. long.

The width at subgrade is 20 ft., and on this are laid two lines of rough stone curbing 8 x 8 ins. in section, 16 ft. out to out. Broken stone ballast is then filled in to a depth of 8 ins., and covered with 6 ins. of 2-in. stone and 4 ins. of 1-in. stone. The space between the foot of the slope and the inner curb forms a drain, and at every turn and at intervals of 200 ft. are cross drains 18 × 18 ins., built up of dry stone and covered with flat stones. These discharge over the outer slope. All the material was deposited in place by wheelbarrows, and these were utilized for rolling and consolidating the road surface. Boulders were put on the road in staggered rows so that the men had to wheel in zigzag lines, and the boulders were continually shifted so as to leave paths along different parts of the road surface.

A heavy wooden fence is erected along the outer side of the road, having Oregon pine posts treated with carbolineum as a preservative. These posts are 4 × 6 ins., 5 ft. long, with 18 ins. set in concrete, and are spaced 8 ft. apart. The top rail is 2 × 6 ins., secured by ¼-in. bolts. The middle rail is 2 × 6 ins., spiked to the posts; and the lower rail is a batten 1 × 6 ins., spiked.

Much of the road excavation was in rock of different characters. For blasting, 10,000 lbs. of dynamite were used in the hard rock, and 17,500 lbs. of black powder in the soft rock. On the top of the mountain was a great razor-back or ridge of projecting rock, and as many persons had been hurt or killed by masses of rock falling down on the old road, the government gave the road contractors $2,000 to remove this ledge. Holes 4 ins. diameter were bored in the soft volcanic rock by jumper drills operated by long levers, and the bottoms of the holes were chambered out by dynamite. The 19 chambers were then filled with 2,100 lbs. of black powder, and the entire face of the ledge blown down into the valley.

Besides this extra work, the contractors had to repair 600 ft. of the approach, and practically to rebuild 4,600 ft. of road at the lower end, the work done in 1889 having been almost destroyed by storms and washouts. The contract price, as already noted, was $37,500, and the total cost of the work was $40,000, including the extras for blasting, etc.

For the information from which this description has been prepared we are indebted to Mr. John H. Wilson, of Wilson & Whitehouse, the contractors, who has recently visited this country. The same firm has a contract for a 24-mile extension of the Oahu Railway, which is a narrow gage line, 33 miles long. It also expects to bid on the new sewerage system of Honolulu, plans for which have been reported upon by Mr. Rudolph Hering, M. Am. Soc. C. E.

The locomotives for the Oahu Railway & Land Co., mentioned above, have been supplied largely by the Baldwin Locomotive Works, of Philadelphia, Pa., and two consolidation engines were recently shipped by that firm. They are of a pattern used on several narrow gage roads, the frames being put outside the wheels. The feed water is supplied by a Korting injector, or by two brass pumps worked from the crossheads. The general dimensions of these engines are as follows:

Gage	3 ft. 0 ins.
Driving wheels	3 " 0 "
Truck wheels	2 " 1 "
Wheelbase, driving	9 " 10 "
" total	17 " 2 "
Weight on driving wheels	59,000 lbs.
" total	67,000 "
Cylinders	14 × 20 ins.
Boiler (straight top), diameter	4 ft. 0 "
Working pressure	160 lbs.
Firebox (copper), length	3 ft. 5½ ins.
" width	3 " 2 "
Tubes (copper), 100, diameter	2¼ "
" length	14 ft. 0 "
Heating surface, tubes	817.0 sq. ft.
" " firebox	52.5 " "
" " total	869.5 " "
Capacity of tender tank	1,500 gallons
Brake fittings	Westinghouse-American outside equalized brake on driving wheels, tender and train.

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THE ADOPTION OF A STANDARD SYSTEM OF TEST BARS FOR CAST IRON.*

By Dr. Richard Moldenke.

The expansion of the general iron trade within the last quarter of a century has been phenomenal, and is bringing with it the natural demand for further and greater efforts on the part of those engaged therein.

The manufacturer who buys castings has a right to ask for and receive the highest product of the molder's skill, combined with a material best suited to the work and the service it must endure. How shall the consumer know when he is getting the best castings for his purpose, or the founder that he is making them and is thus holding his trade? So far as the material is concerned, only by some means of comparison with well selected standards.

The fact that the knowledge and consequent use of such standards is as yet in a very crude state, as indeed are also the methods by which comparisons are made, will account in a great measure for the many disputes between buyer and seller, leave the foundryman in constant anxiety regarding the behavior of the material after it leaves his eyes, and will sometimes make him feel that the quality of this daily product is a matter of mere guess-work.

Early attempts at securing uniformity in testing materials for structural purposes emanated from the parties most interested, not only great consumers, but the actual owners of the works turning out these products. The supposedly disinterested portion of the trade, the practical investigator and the scientist, is only now coming to the front as an aid in solving problems well known to exist but not easy to fathom out.

A real need exists for means of comparison with standards by uniform methods. To quote from the report of the famous Munich convention, "It is universally acknowledged at the present day that the testing of materials of construction for their mechanical properties can be productive of comparable results, but only when made in accordance with uniform testing methods."

In matters relating to the founding of iron, commercially we are undoubtedly ahead of European practice. When it comes to a close study of the material we are working with daily, however, continental Europe at least is pushing us very hard.

It remains for us to look more closely at the present status of the testing question from our standpoint as foundrymen, to see what information of value we may derive thereby, and how we can contribute our share to the general understanding of this most interesting material—cast iron.

Through the courtesy of the eminent metallurgists Dr. Wedding and Prof. Martens, of Berlin, I have obtained information regarding the German practice, which is also said to be in current use in Continental Europe. In substance, it is as follows: Test bars 1 1-5 in. by 1 1-5 in. in cross section and 44 ins. long are cast in dry sand molds inclined 1 in. in 10, the runner acting as feeder and pressure head corresponding to a vertical height of 8 ins. An extension 1 × 1 in. is cast on the bar from which 1-in. cubes can be cut for compression tests. Of the 44 ins. only 40 are intended for testing purposes, the transverse being the first method applied. For this purpose three of these bars are taken and their resistance to bending up to rupture together with the corresponding deflection noted. Two test pieces are turned up from the broken parts of each of the three bars for tensile tests, each piece being 8 ins. long, and 0.8-in. in diameter. Furthermore six compression tests are made with cubes cut from the broken test bars above mentioned, two from each bar, the pressure being applied as if the original piece were used as a column.

Two points of special interest to foundrymen are added as foot notes by the commission which labored to draw up these specifications. The regret is expressed first that the area of cross section of these bars is so small, and second that sufficient experience in casting bars on end is lacking. This would seem to imply, and rightly too, that this method of casting is the preferable one. I might add that the neglect of a proper regard for the teachings of experience in both of these directions will prove fatal to any testing system which may be devised.

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*Condensed from a paper read at the Third Annual Convention of the American Foundrymen's Association, Cincinnati, O., June 7-10, 1898.

While tests similar in part to the above are in use in isolated instances in England and America, yet the testing of cast iron, so far as a uniform system is concerned, is in a truly chaotic state. Indeed, the famous English metallurgist, Mr. Hadfield, of Sheffield, writes me deploring the lack of uniformity in this regard and wishes us success in accomplishing something of practical value in this broad and imperfectly cultivated field.

It is, however, not to be understood that there has been a lack of practical and hard work in this direction by our investigators.

There is a live and healthy movement in progress, in which it seems to me the time has come for us foundrymen to take part.

The question of testing cast iron is not as simple as it looks. Take the constitution of the metal in its broadest sense, and you have essentially a mineral which may but very likely will not, be uniform in its structure. Some portions then are bound to be weaker than others, and to my mind only a plentiful multiplication of these variations, or in other words a good big cross section, will give approximately correct results.

The judging of quality in a material by means of test bars can only be a relative one. Cast iron remains just as cast. As there is no possibility of wiping out the chilling effect of the mold, the variation in structure due to casting temperatures, rate of cooling, etc., the test bars by which a casting is to be judged should approach as nearly as possible the peculiar conditions obtaining at the time. Is this possible or practicable? I fear not. And this is why there is such diversity of opinion on the subject among practical foundrymen.

A review of the results obtained by the committee on testing methods of the American Society of Mechanical Engineers corroborates this, the discussions showing that while the results themselves can and will stand upon their own merits, their interpretation is by no means settled, and will change as our insight into the material becomes better. It is therefore very proper that the final report should be delayed until all the data are thoroughly digested and every hiatus is filled out by the results of new lines of research.

What foundrymen want just now is some system which will become quickly available, based, if possible, upon the experience already at hand, or requiring only a short time to perfect—a system which is cheap, quickly and easily carried out, and which gives trustworthy results. It has always struck me that the existing methods are not practical enough. Thus the German specifications present difficulties of a serious nature. Casting 44-in. test bars of so small a cross section is not likely to give reliable results. The compressive tests of cubes of cast iron are not often carried out in this country, although cast iron is essentially the material best suited for compressive strain. Test bars turned down from square bars to round ones only 0.8-in. diameter will have four hard and four soft spots, so to speak, in the circumference of their fracture area. On the score of reliability and cheapness the German system therefore leaves much to be desired.

In daily foundry practice, when a contract for regularly furnishing certain kinds of castings is received, it is customary to break up the first one made to detect, if possible, any weakness due to the methods of molding employed. At the same time the iron used, the methods of pouring it, etc., come in for their share of close scrutiny. If this is not done the lesson is liable to be brought home very soon by the customer. Railroads do this with their own car wheels, axles, couplers, etc., as a regular method of testing the quality of the material on which so much depends. While this is the best way to assure oneself of the actual condition of affairs the thing is not always practicable in the foundry trade. The next best method would be to cut out test pieces from finished castings rejected for some surface blemish not due to extremes of temperature of the iron poured. An opinion must now be formed as to the quality of the material and its adaptability for the purpose intended, and whatever system of testing is used for the daily work; this trial should always be made whenever expedient, to establish a relation between the general run of the metal and the actual results.

Now as to the regulation test bars which should show the quality of the material poured into castings. I will say at the outset that in my opinion a system involving the reproduction in every detail of the conditions coincident with the making of a casting, though very desirable, is a simple impossibility, and no reconciliation of opinions herein need be attempted. The only solution possible seems to be in avoiding as many of the disturbing influences as possible, and in this way aim to get the value of the material poured into the castings while in its best condition, rather than to obtain a poor imitation of the actual work. Good iron can easily be made worthless to a customer through poor molding and casting methods, but it would be folly to expect good castings with poor iron.

For the tensile test, then, a bar should be round and of large diameter. The peculiar requirements of the transverse test seem to demand a square and thick bar. Test bars should all be cast verically to avoid the variation in strength in the upper and lower sides when cast flat. The effect of a dry sand mold should be obtained to remove all disturbing influences due to the varying dampness of green sand molds. These are a few of the points to be considered in the making of the test bar, its preparation for the machine requiring further study. It remains for us to strike the best average of these variables, which from the nature of the case cannot be converted into constants, and this brings me to the following recommendations.

First.—That the American Foundrymen's Association authorizes the appointment, by the president, of a committee on standard specifications for testing cast iron.

Second.—That the American Foundrymen's Association become a member of the International Society for the Unification of Methods of Testing Materials of Construction, following in tihs respect the example of all other large societies interested in industrial progress.

If I may be permitted to add a few suggestions concerning the work of such a committee, I would advise, first of all, friendliness and co-operation with all others engaged in the same lines of work. Next a careful study of the results already published, and a tabulation of what in the light of our present knowledge of cast iron is of real value. In the meantime a discussion of this subject by the various local foundrymen's associations would doubtless bring out much of value from the personal observations of the members and their friends. Some experimenting will be necessary, and plenty of hard work will surely fall to the lot of those honored by a call of this kind. It will be desirable to have a report prepared for our next meeting, even if not complete or wholly satisfactory to all; for what the foundrymen want is an immediate result in some definite direction. A report of this kind, if of sufficient value, can then be adopted tentatively pending further enlargement or improvement until finally merged into an international code for testing cast iron, in which I hope our American foundrymen will be heard from.

THE BOSTON DEPARTMENT OF MUNICIPAL STATISTICS.

Within about a year the cities of Boston and New York have each established departments of municipal statistics. Such departments have given great satisfaction abroad and are designed to show the various activities of the cities which they serve with a view of aiding in attempts to solve the problems of city administration. Most of the important branches of our city governments issue some kind of a report each year, but oftentimes these reports are perfunctory, and they are liable to change so much in character from year to year as to render their information of little value for comparative purposes. In addition, each department makes its reports without regard to those of the other departments, the methods of bookkeeping and the fiscal years often being different.

The ordinance establishing the Boston Department of Municipal Statistics prescribes the duties of the department as follows:

> Said board shall collect, compile and publish such statistics relating to the city of Boston, and such statistics of other cities, for purposes of comparison, as they may deem of public importance.

The board consists of six members, including the city engineer as ex-officio. The other five members are appointed by the mayor. The present report outlines the proposed work of the board and makes some suggestions regarding uniformity of accounts of the various departments. It has grouped the various activities of the city under seven heads, as follows:

I. Central Organization.

1. City hall.
2. Executive head.
3. Legislative head.
4. Treasurer.
5. Clerk.
6. Law department.

II. Public Safety.

1. Militia.
2. Police or watch.
3. Lighting of streets.
4. Petty courts.
5. Inspection of buildings.
6. Fire patrol.
7. Penal institutions (jail).

III. Public Health.

1. Health officers.
2. Quarantine.
3. Cemeteries.
4. Street cleaning.
5. Removal of garbage.
6. Drainage.
7. Hospitals.

IV. Public Education.

1. Schools.
2. Libraries.

V. Public Conveniences.

1. Maintenance of streets.
2. " bridges.
3. " ferries.
4. Water supply.
5. Markets.
6. Dock facilities.
7. Weights and measures.
8. Regulation by license or inspection:
    (a) Of liquor traffic.
    (b) Of other trades.

VI. Public Charities.

1. Poor relief.
2. Almshouse.
3. Other institutions.

VII. Public Recreation.

1. Parks.
2. Playgrounds.
3. Baths.
4. Music.
5. Celebrations.

The report states that this classification is tentative. It is questionable if water supply might not have been put under Public Health, instead of Public Conveniences, just as properly as drainage is included under Public Health. A large part of the expenditure for water supply, especially the initial outlay, is for fire protection, and thus belongs as properly under Public Safety as does the fire patrol. If we may venture an opinion on a branch of the public service so foreign to engineering as the regulation of the liquor traffic, we should say that this subject belongs much more properly under Public Safety than under Public Convenience. Exception may be taken to the use of the word drainage, as including both sewerage and drainage. This use is more noticeable in view of the fact that it is to Boston engineers that we are largely indebted for emphasizing the distinction between a sewer and a drain.

The work of the Boston Department of Municipal Statistics bids fair to be full of interest and value. Properly compiled, municipal statistics would be of great value both locally and for cities as a class. Citizens wish to know what is being done for them, and to compare their various departments with each other and with similar departments in other cities. Municipal officers need statistics for much the same purpose. We shall look forward with interest to the reports of the Boston and New York Boards after they are put in full working order.

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A REMARKABLE PROPERTY OF ALUMINUM is described by Mr. J. B. Nau in "The Iron Age" of June 16, referring to a paper on the subject read by Hans Goldschmidt before the Electro Chemical Society at Leipzig and a paper published by Leon Frank in the "Chemiker Zeitung." If a mixture of metallic aluminum and the oxide of another metal be heated at one point to a high temperature the oxygen leaves the other metal and oxidizes the aluminum, generating heat of an exceedingly high temperature, which continues the operation until the reaction is complete and the oxide is reduced to a metal which is free from aluminum. Instead of oxides, sulphides may be used, but the heat developed is less than with oxides. The process may be used for generating heat for the production of metallic alloys for brazing, welding, perforating iron plates, etc., and for the reduction of metals from their oxides. Among the metals which have been obtained in this manner are chromium, manganese, iron, titanium, barium, wolfram, molybdenum, nickel, cobalt and vanadium. Alloys of barium with lead and with iron, ferro-titanium and other alloys have also been made.

THE ZERMATT-GORNERGRAT ELECTRIC RACK RAILWAY.

The valley of Zermatt includes some of the grandest scenery in Switzerland, and since 1891 it has been connected with the general railway system of the country by a mixed adhesion and rack railway, 21.7 miles long, connecting Zermatt with Visp, in the valley of the Rhone. This line rises in its course from 2,132 ft. above sea-level to 5,271 ft. above this level. The majority of the tourists visiting Zermatt ascend to the summit of Gornergrat, 10,286 ft. above the sea, to enjoy the magnificent panorama spread before them at that altitude. To make this ascent of over 5,000 ft. in about 5.6 miles by means of a railway involved many difficulties. The route was covered with snow for the greater part of the year, and it was a question whether the number of travelers likely to make this ascent in three months of the year would warrant the outlay of the $700,000 which a rack railway was estimated to cost.

After a close study of all these conditions, Messrs. Haag and Greulich, in 1895, obtained a concession for the construction of an electric rack railway, which is described and illustrated at length in the "Le Genie Civil," and from that article the following abstract is made: The point of departure at Zermatt is the depot of the Visp-Zermatt Railway. Soon after leaving this point an incline of about 12% is encountered, 0.8 miles long, and leading to the viaduct over the Findelenbach. This viaduct, built by Thos. Bell & Co., of Kriens, is 393.6 ft. long and is made up of three steel arches resting on two masonry piers, 151 and 170.5 ft., respectively, above the water in the Findelenbach. After leaving the station of Findelen, beyond the bridge, a grade of 20% is encountered, and this is continued to the end of the line; excepting only some short levels at the several stations. There are five tunnels on the line, generally short, and the completed line has a length of 5.76 miles, with a total rise of 5,248 ft. Vignoles rails are used with an Abt rack-rail between them.

The motive power is electric, on the overhead trolley system, and the total weight of the train to be moved was figured at about 63,800 lbs., including in this the locomotive, two carriages for 110 passengers, and the electrical equipment. For this load on the above grade 160 HP. was deemed necessary, and to this was added 20 HP. to compensate for loss in transmission of power between the axles and motors, or 180 HP. in all. To provide for two trains on the line at one time this had to be doubled; and to compensate for loss at the generators, in the feeders, transformers, etc., a total power of 510 HP. was figured at the turbines to be used, and the turbine unit was fixed at 250 HP. But the actual installation included three units, or one in reserve, and the plan of the turbine-house provided for four units of 250 HP. each, with the view of later using this surplus power either in increasing the railway service or in lighting hotels at Zermatt.

The hydraulic power was obtained from the Findelenbach, where water was taken near the bridge, at an elevation of 5,882 ft., and an effective head of 333 ft. was secured with an abundance of water during the period of operation of the line. The conduit leading to the turbines was divided into two distinct parts; the first was excavated in the rock, sometimes in tunnel and sometimes open, and was 656 ft. long. The second part, of equal length, had a mean incline of 30°, and was made of a riveted steel pipe, 2.95 ft. diameter, and built in sections 19.7 ft. long. Between these two sections of conduit was a reservoir, with an overflow into the Findelenbach.

The turbines are mounted on horizontal axles, and run at 400 revolutions per minute; they are provided with a very sensitive special hydraulic regulator. They were joined directly to the alternators by means of elastic couplings. The exciters are continuous current machines of about 20 K-W. and are coupled to small independent turbines which run at a speed of 900 revolutions. Each of these continuous current machines is of sufficient capacity to excite the three alternators.

As it might happen that three loaded trains would start or stop simultaneously, a sudden variation in load, from zero to 500 HP. and the reverse had to be provided for. The automatic regulation of the speed was, therefore, of great importance. Besides the usual automatic regulator, there was also a compressed air reservoir, with the compressor operated by a small special turbine. This automatic regulating device is not illustrated or described; but mention is made of the fact that a very complete filter plant had to be erected to prevent interference with the working of the regulator by reason of the sand, leaves and ice, so common in mountain streams. Experiments made at the central station, however, show that the variation in the number of revolutions of the turbine shaft between the full load and no load, never exceeded 1%.

The generators were made by Brown, Boveri & Co., after their usual model, and the tension produced in the generator is 5,400 volts. This high tension is reduced to the 540 volts, necessary for the trolley wires, in three station transformers; the first of these is in the central station, the second is 0.3 miles away, and the third is 0.5 miles away. Each of these stations has a transforming capacity of 180 K-W., and is made up of two groups, each, including three monophase transformers of 30 K-W. each. The high tension transmission line is made up of three wires of 5.5 mm. diameter, to No. 2 station, and three 4 mm. wires between stations 2 and 3. From each of these transforming stations 1 and 3 is a secondary feeder, made up of two 8 mm. wires, leading to the two ends of the trolley wire. These are the only feeders in the installation. The two trolley wires are each 8 mm. diameter, supported every 65 or 100 ft. by transverse wires. The rails serve for the return current, and these rails are connected by the "Chicago railbond."

The electric locomotive used weighs about 10.5 metric tons, and it is provided with two motors, each capable of developing a maximum of 90 HP., with 800 revolutions per minute. These two motors are completely independent, and each operates two toothed wheels engaging with the Abt rack-rail. Two trains of gearing reduce the speed from 12 to 1. The regular speed of the train is 4.34 miles, or 7 kilometers, per hour, and the maximum tractive effort is about 13,200 lbs. The locomotive is provided with two hand-brakes, and with an automatic brake which acts when the current is broken or the speed exceeds a certain limit. This last brake may also be operated by the conductor. The entire locomotive rests, on springs, on two axle-bearings independent of the motor axles, upon which are mounted the toothed wheels. The play of these springs is limited, so that the toothed wheels will always engage with the rack. The locomotive, carriages and stations will be lighted by electric light.

On Dec. 1, 1897, the central station was practically finished, and about one mile of the line had been constructed; and it was expected that the line would be opened to the public on July 1, 1898.

BOOK REVIEWS.

GOOD CITY GOVERNMENT.—Proceedings of the Louisville Conference for Good City Government and of the Third Annual Meeting of the National Municipal League, Held May 5, 6 and 7, 1897. Philadelphia: National Municipal League. Cloth; 6 × 9 ins.; pp. 294. $1.

This volume contains nine papers on various phases of municipal government by Prof. Frank J. Goodnow, Prof. Leo S. Rowe, Mr. Clinton Rogers Woodruff, Secretary of the National Municipal League, and others; also papers describing municipal conditions or reforms in Providence, New Haven, Rochester, Philadelphia, Charleston, S. C., Ohio cities, New Orleans, St. Louis, Kansas City and San Francisco. The various papers and discussions are full of suggestions to those interested in good municipal government. The volume is well made in the matter of typography, paper, presswork and binding.

METHODS FOR THE ANALYSIS of Ores, Pig Iron and Steel in Use at the Laboratories of Iron and Steel Works in the Region about Pittsburg, Pa. Together with an Appendix containing various special Methods of Analysis of Ores and Furnace Products. Contributed by the Chemists in charge and edited by a Committee of the Chemical Section, Engineers' Society of Western Pennsylvania, Easton, Pa. Chemical Publishing Co. Cloth; 8vo.; pp. 133. $1; paper, 75 cts.

The methods in use in the iron and steel laboratories of the region near Pittsburg, Pa., were collected and published by the Engineers' Society of Western Pennsylvania during 1896. The supply of copies having been exhausted, in response to a continuous demand, the publication in more convenient form has been undertaken by the Chemical Publishing Co., who have been authorized to do so by resolution of the Society. Sixteen different laboratories have contributed descriptions of their methods, and an appendix contains brief papers by seven chemists on special determinations. The book is a welcome addition to the literature of iron and steel chemistry.

DIVISION OF HYDROGRAPHY OF THE U. S. GEOLOGICAL SURVEY.—Operations at River Stations, 1897. Parts I. and II. Nos. 15 and 16 of the Water Supply and Irrigation Papers. Mr. F. H. Newell, Hydrographer in Charge. Washington, D. C.: Government Printing Office. Paper; 9 × 5¾ ins.; pp. about 100 each.

Part I. includes data upon the Chesapeake Bay watershed; basins of the Potomac and James Rivers; the South Atlantic watershed; Gulf of Mexico watershed; drainage basins of the Ohio, Upper Missouri and Platte rivers. Part II. includes notes upon the drainage basins of the Kansas, Arkansas, Rio Grande, Colorado and Humboldt rivers; the drainage basin of the Great Salt Lake; that of the Columbia River and the watershed of San Francisco Bay. These notes give daily gage-heights at a number of stations for the year 1897, and in many cases the discharge in feet per second. The text in each case indicates the local conditions under which the observations were made. The 19th Annual Report of the Survey will contain diagrams showing the computed monthly and average discharge for the year; but Mr. Newell has considered it advisable to issue this preliminary information for those who may have use for it before the more elaborate report is issued.

THE RESISTANCE AND PROPULSION OF SHIPS.—By William F. Durand, M. Am. Soc. C. E., Principal of the School of Marine Construction, Cornell University. New York: John Wiley & Sons. London: Chapman & Hall, Limited. Cloth; 8vo.; pp. 431; 117 illustrations. $5.

The object and scope of this work are well shown in the following extract from the preface:

> During the last twenty or thirty years the literature relating to the Resistance and Propulsion of ships has received many valuable and important additions. Of the few books in English published in this period, those of the highest value have been restricted either in scope or in mode of treatment. For the most part, however, the important additions to the subject have been published only in the Transactions of engineering and scientific societies, or in the technical press. Such papers and special articles are far from providing a connected account of the trend of modern thought and practice, and the present work has been undertaken in the hope that there might be a field of usefulness for a connected and fairly comprehensive exposition of the subject from the modern scientific and engineering standpoint. With the material drawn from the general literature of the subject there has been combined a considerable amount of original matter.
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> A free use has been made of calculus and mechanics in the development of the subject, the nature of the treatment requiring the use of these powerful auxiliaries. At the same time most of the important results and considerations bearing on them are discussed in general terms and from the descriptive standpoint, and all operations involved in the actual solution of problems are reduced to simple expression in terms of elementary mathematical processes.
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> The work represents substantially the lectures on Resistance and Propulsion given by the author to students of Cornell University in the School of Marine Construction, and many features both in subject-matter and mode of treatment have been introduced as a result of the experience thus obtained in dealing with these subjects.

The several chapters of the book are as follows: Resistance, 156 pages; Propulsion, 48 pages; Reaction between Ship and Propeller, 32 pages; Propeller Design, 67 pages; Powering Ships, 33 pages; Trial Trips, 49 pages. The style of the author is plain, logical and concise, and, while some of the mathematical part is difficult, it is not more so than the nature of the subject requires. Professor Durand has in the production of this work rendered a most valuable service to all students of marine engineering, to whom it should prove almost indispensable.

THE GAS ENGINEER'S POCKET-BOOK; Comprising Tables, Notes and Memoranda relating to the Manufacture, Distribution and Use of Coal Gas and the Construction of Gas Works. By Henry O'Connor, Associate Member of the Institution of Civil Engineers, Vice-President of the Society of Engineers. New York: D. Van Nostrand Co. Morocco; 4¾ × 6¾ ins. pp. 438. $3.50.

This pocket-book is compiled by a British engineer who resides in Edinburgh. About one-half of the book is devoted to compilations of ordinary pocket-book information, such as mathematical tables, brief statements concerning the strength of materials, boilers, chimneys, engines, gearing, etc. The remainder contains matters of special interest to gas engineers, such as the construction of retort houses, condensers, exhausters, scrubbers, purifiers and gas holders, and notes on retort house working, condensing washing and scrubbing, distributing gas, testing and enriching. The pocket-book is evidently written by a gas engineer of wide experience. He states in his preface that the work is based upon notes collected during the course of his professional career, originally intended only for his personal use; but he has also made use of articles in the "Journal of Gas Lighting" and "Gas World" for a considerable portion of the matter. The work will no doubt prove a handy book of reference for gas engineers, although many of its statements will need to be checked by reference to standard works on gas engineering. The first part of the book, containing general engineering information, contains many defects, due apparently to hasty preparation. For instance: On page 338 a table of the Latent Heats of Fusion is given, and immediately below is another table of "Latent Heat of Liquefaction," without any indication that they are both the same thing except that one is apparently Centigrade and the other Fahrenheit. The latent heat of liquefaction of "water at 39° F." is given as 142.65: what the latent heat of liquefaction of water at 39° F. is can only be guessed. The author probably means the latent heat of liquefaction of ice at 32° F. On the same page he gives a table of Comparative Powers of Solids for Conducting Heat, and immediately below another table headed "Relative Heat Conductivity of Metals," which two tables one would suppose would relate to the same thing; but the figures are entirely different. In the first table silver has a relative value of 973 as compared with gold 1,000. In the second table silver is 1,000 and gold 981. In the first table aluminum is 305 and in the second 665. The second table is also given in an extended form on page 97. On page 166 the British thermal unit is defined as the amount of heat required to raise one pound of water from 60° to 61° F. On page 340 the "Thermal Unit" is the amount of heat required to raise a unit weight of water through 1° Centigrade. The "Board of Trade thermal unit" is "the amount of heat necessary to raise one pound pure water 1° F. from 39.1 to 40.1 F.," and "a calorie is the quantity of heat necessary to raise 1 kilogram pure water 1° Centigrade." This is the worst mixture of definitions of thermal units that we have ever seen. What is given as the Board of Trade thermal unit is what is usually known as the British thermal unit, as defined by Rankine and other writers, and what the author defines as a "thermal unit" is what most writers call a calorie. The mechanical equivalent of heat is given as 772 ft. lbs, but modern writers are almost universally using 778. This portion of the book might be much improved by revision.

STREET CLEANING IN THE CITY OF NEW YORK, 1895-6-7.—By Geo. E. Waring, Jr., Commissioner. Supplement to "Municipal Affairs" for June, 1898. New York: Reform Club, 52 William St. Paper; 6 × 9 ins.; pp. 234; illustrations and tables. 50 cts.

Probably there are few achievements in municipal administration that have attracted more attention than the work of Col. Waring during the three years covered by this report. The street cleaning department of our greatest American city had become a reproach to the city itself and to city government in a democratic country. In a few months all this was changed and the streets of New York became as notable for their cleanliness as they had been before for their foulness. The way in which the transformation was effected will long serve as an example of the difference between a business and a political administration of city affairs. Our readers cannot but feel gratified that the man at the head of this reform was an engineer, and that his executive staff was very largely made up of engineers, mostly young men, many of them not long out of technical schools and colleges. No better refutation could be asked of the absurd charge sometimes made that engineers lack business ability, while the condition of the street claining department when Col. Waring took office, and its previous history, is the best possible illustration of the failure of the so-called practical politician as a city official and of the iniquities of the spoils system. One of the most remarkable features of this reform is that it was accomplished with very much the same force of laborers and foremen as were found at the brooms, on the carts and in the stables and shops when Col. Waring assumed charge of the department.

In view of the facts outlined above, it is not strange that the present administration of New York city, Tammany having again come into control on Jan. 1, should refuse to give Col. Waring's report the publicity it deserves, so that it should be made generally available by the Journal named above, instead of by the city itself.

A large part of the matter in the volume before us was published in the New York "City Record," for Dec. 30, 1897, just before Col. Waring went out of office, and most, if not all of the balance has appeared in print before this, some in the special report on garbage disposal published by the city in 1896, and some in Col. Waring's book on "Street Cleaning" and allied subjects, noticed in our issue of April 14, 1898. It was, however, highly desirable that the result of these three years work should be made available in one convenient publication, and this the Reform Club of New York city has done.

The bulk of the general report, as is natural under the circumstances, is made up of special reports by Col. Waring's heads of departments and other assistants. Col. Waring contributes a brief introductory statement and also some 70 pages of "Observations on Street-Cleaning Methods in European Cities." These observations, slightly abbreviated, are included in the book on "Street Cleaning," mentioned above. They were made during a visit by Col. Waring, in 1896, to eleven of the principal cities of Europe.

About 16 pages are occupied by the very interesting report of Mr. Geo. L. Walker, Master Mechanic of the department. This report includes descriptions and illustrations of some features of the stables, and of the new dumping boards and steel storage pockets for street sweepings and other refuse. Mr. Chas. A. Meade, Superintendent of Final Disposition, reports on the subjects connected with his department, taking up dumping at sea, the filling in of low submerged lands around Riker's Island, and the sorting of light rubbish for the purpose of reclaiming salable material and burning the balance.

"Special Reports on Waste Disposal" include "The Private Collection of Garbage," "The Garbage Tankage Trade" and "The Traffic in Waste Paper," by Mr. Hawthorne Hill, and "The Fuel Value of Waste Ashes" and the "Utilization of Fine House-Ash in Building," by Mr. C. Herschel Koyl. Mr. Koyl also contributes a valuable study of "Factors in the Cost of Street Cleaning," accompanied by many detailed tables. This is one of the most unique features of the report. It is based on measurements of the various kinds of paving in the several street cleaning districts of the city, the pavements being further divided into "good, fair or bad." It is also based on the amount of car traffic; the length of street car track; the kind of rails used for surface railways; the sanding of railway tracks; the amount of street sprinkling; the presence or absence of elevated railway supports; the character of the population; the number of schools, market-stores and push-carts; and the nearness of unpaved streets.

"The Problem of Snow Removal" is reported on by Mr. H. L. Stidham, Snow Inspector, who gives many details of quantities and cost, both before and during Col. Waring's administration.

Last, but not least in value, interest and suggestiveness, is a brief report on "The Labor Question in the Department of Street Cleaning," by Mr. Thos. A. Doe, Chief Clerk and Secretary of the "Board of Conference." This board consisted of the general superintendent, chief clerk, one district superintendent, one section foreman and one stable foreman, representing the commissioner; and five spokesmen, chosen by the "Committee of 41," described further on, to represent the workmen. The board met regularly, the first permanent chairman being a sweeper elected by the Committee of 41 as one its five spokesmen. The board passed upon complaints, and suggestions made by members of the force, there being an appeal to the commissioner in case of a deadlock and the commissioner's approval being necessary before some of the suggestions could go into effect.

The Committee of 41 was made up of representatives of the employees in the several districts. Individual complaints were discussed by this board and many of them settled without going further. When they could not be settled here, through disagreement or otherwise, they were referred to the Board of Conference. The general results of this method of dealing with labor questions are declared by Mr. Stidham to have been very satisfactory.

The foregoing outline will give a fair idea, we trust, of the contents of this report, a report valuable in itself and made many times more so because of the lack of information on the subject. The small price set upon the report places it well within the reach of all interested in the subject. We suggest that those ordering the report request that the June number of "Municipal Affairs" be sent to them also. The publishers offer to do this without extra charge, and every number of this quarterly thus far issued has contained valuable material. The bibliography of periodical literature on municipal government, which includes engineering as well as other subjects, is alone well worth the price of the Journal. The publication not being for private gain, it seems proper for us to suggest that instead of sending 50 cts. for the street cleaning report and the June number that $1 be sent for a year's subscription, to begin with June and include the present report.

ANNUAL CONVENTION OF THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

(Concluded from p. 407.)

Closing Session.

The time of the last session of the convention was chiefly taken up with the election of officers and other routine business, there being only two of the special committee reports remaining for consideration. The first of these reports was that of the committee on "Air Brake and Signal Instructions," which had been prepared jointly with a committee of the Master Car Builders' Association, as was stated last week in the report of the proceedings of that association. Some discussion followed as to the best manner of disposing of this report, and it was finally decided that the rules as revised should be presented in full in the "Proceedings" of the Association as well as in pamphlet form, for sale to the railway companies.

The convention next took up the report of the standing committee on the subject of "The Apprentice Boy." This report presented a formal code of rules governing the training of apprentices, forms of indenture, and schedule courses of study and shop work. Some discussion followed, chiefly in criticism of individual items of the schedule of shop work, but upon the motion of Mr. Wm. Forsyth (C., B. & Q.) the convention voted to recommend the code presented for use in railway shops. This closed the consideration of the reports of special and standing committees, except that of the committee on subjects for the 1899 convention. The subjects suggested by this committee and referred to the Executive Committee for final recommendation were as follows:

1. A research laboratory under the control of the American Railway Master Mechanics' Association.
2. Water purification and the use of boiler purge.
3. Cast-iron wheels vs. steel tires for passenger equipment, including cars, engine and tender trucks.
4. The advantage of the ton mile basis for motive power statistics.
5. What is the best method for applying stay bolts to locomotive boilers, including the making of the bolts and preparing the stay bolt holes.
6. Is it best to have flanges on all the drivers of mogul ten-wheel and consolidation engines. If so, with what clearance should they be set.
7. Is it good practice to make fire boxes with the crown and side sheets in one piece?
8. The use of nickel steel in locomotive construction. Its advantages and proper proportion of nickel.

In his opening address, as was stated in the report of the first day's proceedings, President Leeds spoke strongly in favor of taking steps toward the consolidation of the Master Car Builders' and Master Mechanics' Associations. These remarks led to the appointment of a special committee to present at the last session of the convention such formal recommendations upon this matter as might seem advisable, and following the committee on subjects this was the next committee to report. Their report in substance strongly urged the advantage of consolidation, and recommended that the Executive Committee of the Master Mechanics' Association appoint a special committee of members belonging to both associations for the purpose of devising some method by which consolidation might be secured. The recommendation was adopted by vote of the convention.

The balloting for officers for the ensuing year resulted in the following persons being elected: President, Robert Quayle, Chicago & Northwestern Ry., Chicago, Ill.; First Vice-President, J. H. McConnell, Union Pacific Ry., Omaha, Neb.; Second Vice-President, W. S. Morris, Chesapeake & Ohio R. R., Richmond, Va.; Third Vice-President, A. M. Waitt, Lake Shore & Michigan Southern Ry., Cleveland, O.; Treasurer, J. N. Barr, Chicago, Milwaukee & St. Paul Ry., Milwaukee, Wis.

Topical Discussions.

During the first and second day's session of the convention the noon hour was set aside for a special order of business known as topical discussion. Among the several topics considered in these discussions the following have been selected as of most general interest:

Special Apprentices.—This subject was introduced by Mr. Robert Quayle (Chic. & No'w'n.), who spoke in part as follows: The special apprentice is one who is supposed to come well equipped from some technical school. There are on the Chicago & Northwestern Ry. apprentices of this kind coming from the technical colleges at Yale, Purdue, Wisconsin and Minnesota. When these men are taken on they are given thoroughly to understand that they are to be advanced solely on their merits. They must not only have technical training but they must have ability to apply that training practically in the shops, they must have fitness for the work that they have in hand, and they must make evident to the department that they have not only skill in doing work but the ability to handle men. To demonstrate these points the apprentice is put at various kinds of work in the different departments and is watched step by step in his progress. These apprentices have been found of especial value in the testing department. At first these men were started in at the pay of 75 cts. per day, but recently the company has raised this to $1 per day. No ill feeling is aroused on the part of the general apprentices because they are given to understand that if they show the proper ability they will get as good an opportunity as the others. As yet the company has had no regular course of training for its special apprentices, but it is now at work on such a course for future use.

Arrangement of Locomotive Front Ends to Prevent Throwing Sparks.—The discussion on this subject was opened by Mr. J. H. McConnell (U. P.), who stated that the arrangement of the front end of a locomotive so that it would clear itself of cinders without throwing sparks depended a great deal upon the nature of the fuel used. Where a strong bituminous coal was used, if the engines steamed freely they would clean the front end and not throw sparks if a coarse netting were used and the diaphragm was run pretty well down toward the bottom of the smoke box. An engine which steamed freely usually kept the front end clean. Where the front end filled up the engine was likely to throw sparks. Where lignite coal was used it was a difficult matter to make the engine keep herself clean and not throw sparks. The lignite coal in Wyoming was of much the same character as wood; it required a very fine netting to prevent the throwing of sparks. At the same time the deflecting plate must be dropped down pretty well in order to clean the front end, and the exhaust nozzle must be contracted to overcome the friction of the fine netting and the low deflecting plate. In engines having diamond stacks the petticoat pipe can be arranged in such a way—viz., using rather large nozzles and setting the petticoat pipe 2 ins. above the nozzles, placing them 4 ins. high and leaving a 5-in. opening on the side of the stack—that good results can be got with Wyoming coal and the locomotive will not throw sparks. Some years ago the Union Pacific Ry. had extension fronts, but they had been removed and replaced with diamond stacks.

A letter from Mr. J. L. Lawrence (Cumb. Val.) contained the following discussion of this subject:

> We do not know of any extension front engine that will not throw sparks with the usual grades of bituminous coals, if equipped in the front end in the old way, viz.: the diaphragm back of the exhaust pipe and the entire front provided with netting, if the engine is worked reasonably hard; but with our plan we abolish about 40% of the netting using a solid sheet and put the diaphragm in front of the exhaust pipe, which seems to give a much better and more evenly distributed draft over the flue sheet and flues. We do not think front appliances can be placed in the front end to keep in the sparks without interfering with the draft and steaming qualities of the engine, but the arrangement should be such as to keep the sparks from getting into the front end which we think our plan does. We have, since adopting this method, been enabled to run our heaviest freight engines in local and through freight service for a week or more without cleaning out the front end and have run some of our passenger engines as long as 18 months without cleaning the front, in fact they would never need cleaning, as at the end of this time there was not a bushel of sparks in the front and while we cannot say the engines throw less sparks they certainly do not throw any more than with the old plan and we are using a mesh No. 2½ and No. 12 wire as against No. 3 mesh of No. 10 wire in the old front end. We expect, however, to try and use the No. 3 mesh and No. 10 wire in our latest plan to see if we cannot cut down more of the proportion of sparks thrown than at present.
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> In conclusion we would say that we are controlling to a very large extent, the cinders going into the front end and are throwing no more sparks than before even with a coarser netting.

Mr. G. K. Henderson (Norf. & Wn.) stated that his company had found it advisable to use a low nozzle with the diaphragm brought down back of the steam pipe and then run off horizontally with a netting confined to the extension. There were a couple of petticoat pipes to equalize the draft and it was important to get the lower petticoat pipe down close to the diaphragm sheet. The engines equipped in this manner ran two or three weeks with an accumulation of probably not more than a hat-full of cinders.

Steel in Locomotive Construction.—The discussion was opened by Mr. J. E. Sague (Schenectady Locomotive Works), who spoke of the use of cast steel in locomotive construction. One of its great advantages was a reduction in the weight of details. The best quality of cast steel for locomotive work had not been determined, but in practice a steel of low tensile strength and great toughness was generally employed. The objections to the use of cast steel was its greater shrinkage in casting, its rougher surface requiring a greater amount of machine work, and its hardness which made this machine work difficult. The use of cast steel in place of cast iron increased the first cost, but this was offset by increased efficiency and the reduction in repairs.

Mr. G. R. Henderson (Norf. & Wn.) stated that his company had recently been making the main driving axle and crank pins of locomotives from nickel steel. Ordinarily the main axle was made ⅛-in. larger than the other axles, and the idea of using nickel steel was to do away with this difference by using a stronger material instead of greater dimensions to secure the extra strength required of the main axle. Mr. Robert Miller (Mich. Cent.) also stated that his company had recently used nickel steel crank pins in three new pony engines.